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This study was conducted to determine the probability of a consequential hazardous substance spill in the St. Clair/Detroit River System area as a result of navigation in both winter and non-winter periods. Specifically, the project develops estimates of the numerical probability of a spill occurring on the St. Clair River, Lake St. Clair, and the Detroit River, and the probable type and magnitude of such a spill. The estimates were calculated for the following shipping seasons: 1 April - 15 December; 1 April - 15 January; 1 April - 14 February; 25 March - 15 December; 18 March - 15 December; and Year-round. Keywords: Oil spills, Ship

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Thomas Freitag

22b. TELEPHONE (Include Area Code)
(313) 226-7590

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PROBABILITY OF HAZARDOUS SUBSTANCE SPILLS ON ST. CLAIR/DETROIT RIVER SYSTEM

Contract DACW 35-82-C-0049

November 1982

Robert H. Schulze
and
Michael Horne

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I. EXECUTIVE SUMMARY

Objectives

1.01 The objective of this study is to determine the probability of a hazardous substance spill in the St. Clair/Detroit River Waterway System as a result of navigation in both winter and non-winter periods. Specifically, the project develops estimates of:

- The numerical probability of a spill occurring on the St. Clair River, Lake St. Clair, and the Detroit River

- The probable type and magnitude of such a spill

These estimates are calculated for both winter and non-winter periods for each of the following shipping seasons:

- 1 April to 15 December
- 1 April to 15 January
- 1 April to 14 February
- 25 March to 15 December
- 18 March to 15 December
- Year-Round

The St. Clair/Detroit River Area

1.02 The St. Clair River is the northern segment of the St. Clair/Detroit River System connecting Lake Huron and Lake Erie. The St. Clair River extends from Lake Huron to Lake St. Clair, which is a shallow basin that serves as a connecting waterway between the Detroit and the St. Clair Rivers. The Detroit River is the southern section of the system connecting Lake St. Clair to Lake Erie.

1.03 Ice can be expected to be a winter hazard to navigation in the St. Clair/Detroit River System. Ice jams sometimes occur in the narrow entrance to the St. Clair River under the Blue Water Bridge. During breakup large ice floes may also jam in the lower St. Clair River. Lake St. Clair is shallow and therefore reacts quickly to wind conditions and temperature changes to form ice. During the period of greatest ice cover, there is thick, fast ice in the bays and protected areas, and heavy consolidated floes of brash and cake ice in the midlake shipping channel. Since this ice moves, the cut channel can also move, which can be a danger to navigation. Although the

Detroit River generally remains clear of ice, the upper River may have some jams as ice is released from Lake St. Clair. The lower section of the Detroit River sometimes has some freeze-over and ice jams.

Operational Assessment of Accident and Spill Potential

1.04 Senior U.S. Coast Guard officials responsible for safe navigation in the St. Clair/Detroit River System were interviewed to develop an operational assessment of the hazards of operating in the St. Clair/Detroit River area beyond the limits of the traditional season. Questions in the interviews emphasized the problems of operating in ice and other winter hazards to navigation.

1.05 Aids to Navigation. Winter navigation in the St. Clair/ Detroit River System is more difficult because channel buoys are removed. Navigating the long channel across Lake St. Clair presents some problems when the buoys are removed. Upbound, mariners sight astern on the Peach (Peche) Island range at the head of the Detroit River to stay in the channel. The fixed Lake St. Clair Light marks the center of the Lake and a slight left turn as the channel continues to the St. Clair River. When visibility conditions are low, these navigation aids are likely to be obscured. Ships may either stray out of the channel because of reduced visibility or they may be forced out of the channel by shifting ice fields. Navigating with buoys removed is less of a problem in the St. Clair River and the Detroit River because the channels are generally deep and radar provides a good aid to navigation.

1.06 Ice Conditions. Coast Guard officers and fleet operators report that the Detroit and St. Clair Rivers are generally ice free because of high currents. Ice obstructions are generally caused by ice jams rather than a freeze-over. At the northern end of the St. Clair River, brash ice sometimes fills the channel to the bottom. Even icebreakers cannot push through this accumulation of ice, therefore navigation stops until the ice is carried away by currents.

General Operational Assessment

1.07 Senior Coast Guard officials responsible for safe navigation in the St. Clair/Detroit River System believe that a higher level of winter shipping activity would not result in more accidents. Navigation procedures may be somewhat different in winter because many buoys are removed, but radar buoys are added at the turns and range lights are available, so that navigation is generally not considered to be more hazardous. Winter ice is not expected to present a special danger to spills of hazardous substances.

Vessel Transits, Accidents, and Spills

1.08 The St. Clair/Detroit River System is a choke point to shipping traffic between the northern three Great Lakes and the ports along the Detroit River, Lake Erie, Lake Ontario, and the St. Lawrence Seaway System to the east. Because of this characteristic, the standard measure of vessel activity in the area is the transit or passage of vessels from one end of the system to the other. Vessel transit information is used as the measure of shipping activity and provides the basis for computing the probability of vessel accidents and spills in the system.

1.09 Figures I-1 through I-3 show seasonal traffic patterns for the St. Clair/Detroit River System. Figure I-1 shows the average number of vessel transits for the St. Clair River from 1974 through 1980. The important thing to note is the trend of the traffic flow and the proportion of each type of vessel that moves each month. Figure I-1 shows that the St. Clair River has no fixed season; traffic flows all year. Although tanker transits drop off in February and March, the difference between these low traffic months and the heaviest loads in the summer is not great. On the other hand, the bulker traffic tends to be more seasonal. Bulker traffic in January, February and March is off sharply from peak summer loads.

1.10 Figure I-2 shows the average number of transits for Lake St. Clair. This section of the system is affected most by winter ice and consequently winter traffic tends to be much lower. Although winter tanker traffic drops off more sharply than in the St. Clair River, this reduction is not nearly as great as for the bulkers. Bulker traffic on Lake St. Clair in the winter is a very small percentage of traffic in the peak summer months.

1.11 Figure I-3 shows that the Detroit River seasonal traffic pattern is much the same. Tanker traffic drops off in the winter but not as much as the bulker traffic. Figures I-1 through I-3 show that vessel traffic in the St. Clair/Detroit River System is indeed seasonal, but the system is active and operating throughout the entire winter.

FIGURE I-1 AVERAGE NUMBER OF VESSEL TRANSITS, ST.CLAIR RIVER, 1974-1980

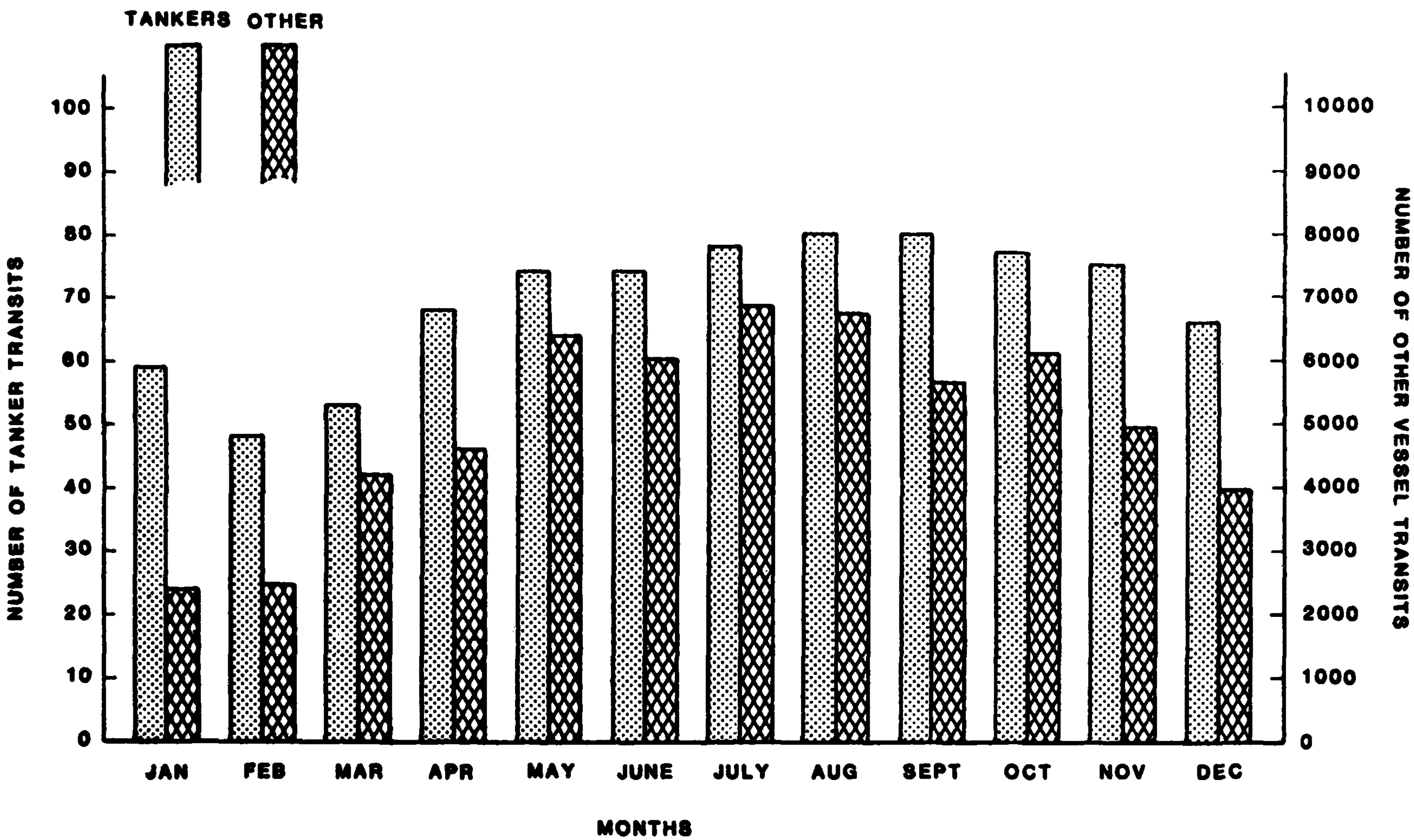


FIGURE I-2 AVERAGE NUMBER OF TRANSITS, LAKE ST. CLAIR, 1974-1979

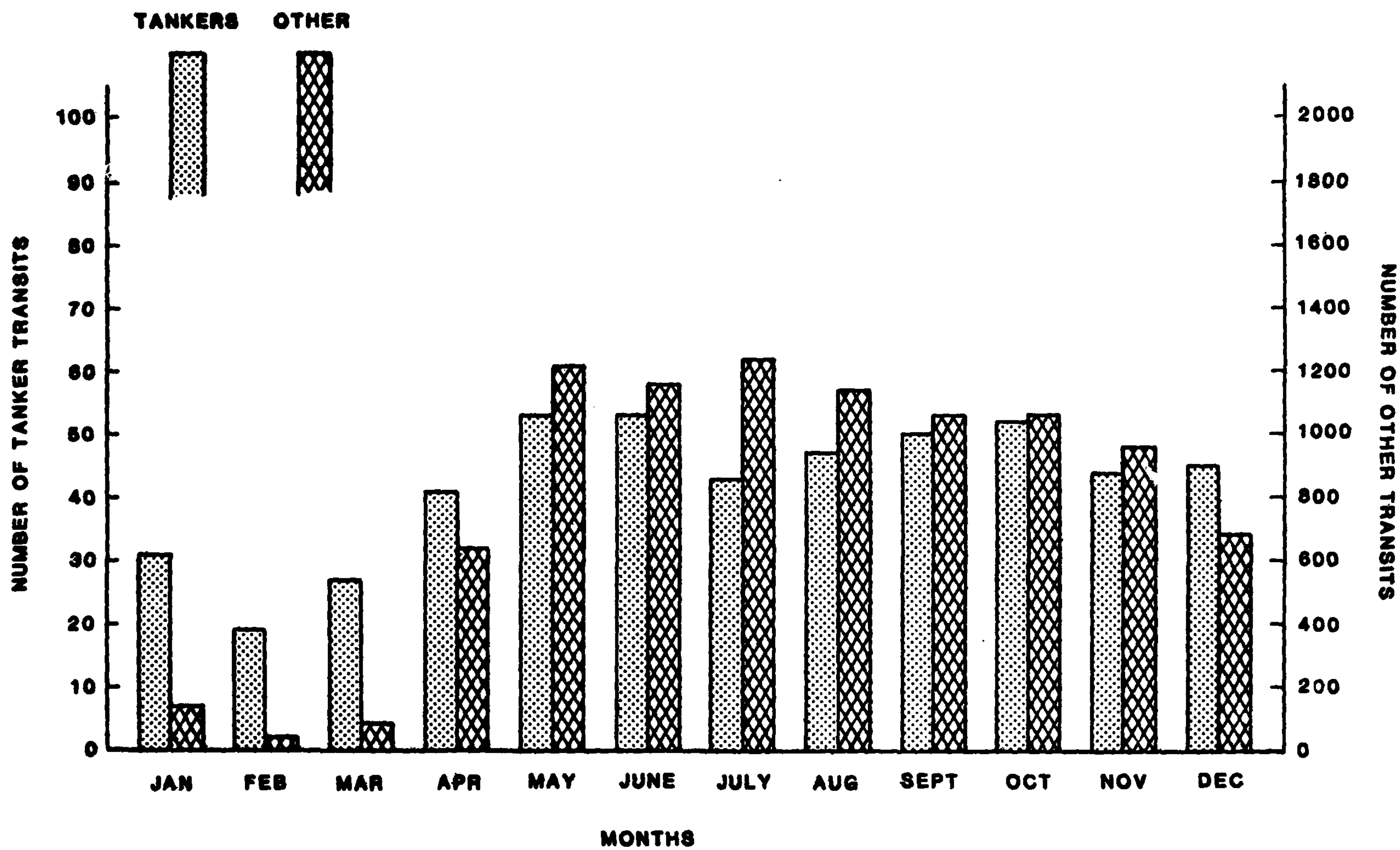
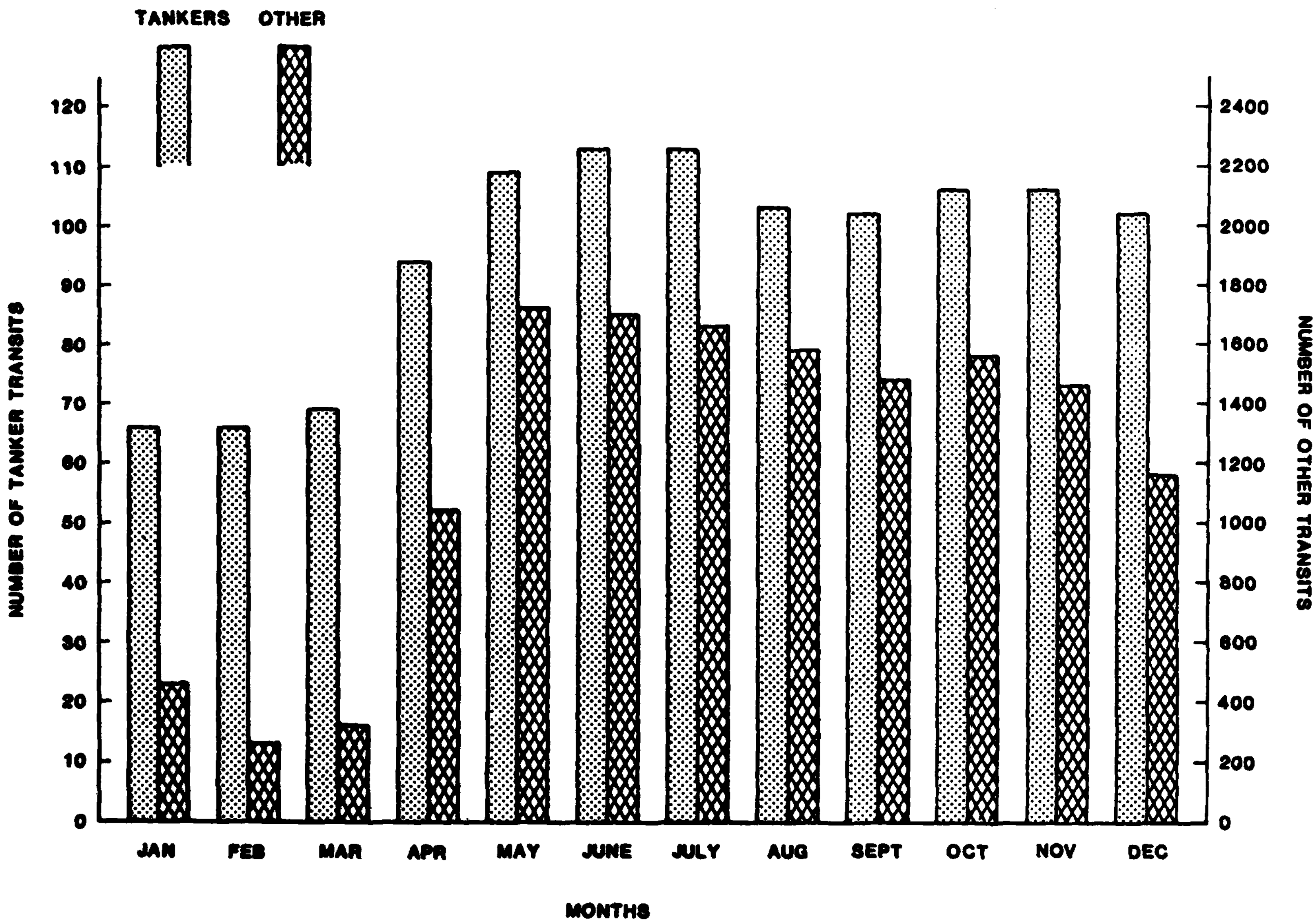


FIGURE I-3 AVERAGE NUMBER OF TRANSITS, DETROIT RIVER, 1974-1979



1.12 Data on vessel accidents used in this analysis are taken from U.S. Coast Guard casualty records. These casualty records tabulate many kinds of incidents. Some of these accidents are clearly accidents that can be related to the hazard of a spill while others cannot. To limit the analysis to mishaps that are related to spills, this study addresses the accident categories of groundings, groundings in ice, collision, and collisions with ice.

1.13 Table I-1 provides an accident summary for the entire area. These records show that although the St. Clair River has many more transits than any of the other sections of the system, the accident rate is very low. For example, the St. Clair River has four times the number of transits as the Detroit River but only 13% of the accidents. This condition can probably be explained by the fact that the St. Clair River does not have much activity in ports and restricted channels. It is also interesting to note that there are not many accidents in ice, only one in a six year period, even though ice sometimes jams at the Blue Water Bridge and in the St. Clair delta.

TABLE I-1 SUMMARY OF ACCIDENT RECORDS, ST. CLAIR/ DETROIT RIVER SYSTEM, 1974 -1979

	GROUNDING	COLLISION	COLLISION WITH ICE	TOTAL ACCIDENTS
St. Clair River	8	3	1	12
Lake St. Clair	13	2	1	16
Detroit River	18	61	11	90
Total	39	66	13	118
Percent of Total	33	56	11	100

1.14 Lake St. Clair has a relatively low number of accidents for a shoal area with a restricted channel. There are not even many accidents in ice even though the Lake is completely frozen over for two months of the year. By far most of the accidents in Lake St. Clair are groundings. Although these groundings present a threat of a spill, none has occurred because the bottom adjacent to the channel is soft mud.

1.15 The Detroit River has a relatively large number of vessel accidents. This is because much of the Detroit River is in an intensely developed industrial area with busy ports. A large percentage of the accidents occur in narrow channels in these industrial areas, such as the Rouge River and the Trenton Channel. Most of the collisions are minor accidents that result from large vessels maneuvering in highly restricted waters.

1.16 Although a great many spills have occurred in the St. Clair/Detroit River area resulting from vessel operations, only a few were the result of a vessel accident. All of the accident related spills occurred in the Detroit River and all ocurred as the result of collisions. Further, all of the spills were very small, only 8 gallons per spill on the average, and records show that 84% of the spilled product was recovered. Based on these records, one could assume that the threat of a major spill event in the St. Clair/Detroit River System is minimal.

Assessment of Spill Risk

1.17 This study determines spill risk by computing the probability of an accident and a spill for the normal navigation season, then uses these results to determine the probability of an accident and spill in the various extended seasons based on the estimated number of transits that would occur in these seasons. By relating the probability of an event to the expected number of transits, it is possible to compute the probability of a spill for any of the season extension alternatives.

1.18 Table I-2 summarizes the probabilities of an accident and a spill for the average normal season (1 April to 15 December) and for the additional transits that would occur during a full season extension. The threat of a spill resulting from an accident is quite low in every case for the normal season and for full season extension the threat is negligible.

TABLE I-2 TANKER ACCIDENT AND SPILL SUMMARY

	AVERAGE NORMAL SEASON	FULL SEASON EXTENSION
St. Clair River		
P_A	0.03	0.003
P_S	0.003	0.0002
Lake St. Clair		
P_A	0.2	0.03
P_S	0.02	0.003
Detroit River		
P_A	0.99	0.10
P_S	0.06	0.006

P_A = Probability that a ship has an accident
P_S = Probability of a spill

Conclusions

1.19 The probability of a spill resulting from a vessel acccident in the St. Clair/Detroit River Waterway System is low. During the time covered by accident and spill records (1974 - 1979), there have been no spills resulting from accidents in the St. Clair River and Lake St. Clair, and three spills resulting from accidents in the Detroit River.

1.20 Senior U.S. Coast Guard officers responsible for safe navigation in the St. Clair/Detroit River System believe that winter operations can be expected to be relatively safe.

1.21 The St. Clair/Detroit River Waterway is nearly a full season system now. Although bulker traffic decreases appreciably in the winter, tanker traffic continues with a much smaller seasonal reduction.

1.22 Oil spills resulting from vessel accidents in the St. Clair/Detroit River System are small in number and small in size. There were no spills caused by accidents in either the St. Clair River or Lake St. Clair during the period of this study. In the Detroit River, there were three spills resulting from accidents that released a total of 25 gallons of oil in the six year period covered in this study. In that same six year period, there were 247 unreported spills that released 66,600 gallons of oil. This means that the number of unreported spills is larger than accident spills by a factor of 82 and the quantity of oil spilled is larger by a factor of 2700.

Recommendations

1.23 Valuable planning information can be obtained by using records of vessel operations to determine the threat of an oil spill in critical shipping choke points. It is therefore recommended that new computations of spill threat be made periodically to assess the impact of changes in traffic levels and operating practices.

1.24 The number of accidents and spills that occur in each section of the Great Lakes Waterway System is often too small to be statistically significant. To improve the confidence level in the computation of the hazards of a spill, it is recommended that the probability of an accident and a spill be computed for the entire Great Lakes area. This analysis would produce the highest possible accuracy for the probability of an accident and a spill because it would cover the entire range of Great Lakes experience. In addition, the study would produce the most accurate information on the expected size of spills because the records of all spills would be included.

1.25 It is recommended that adequate steps be taken to improve oil spill surveillance and enforcement because unreported spills are, by far, the most numerous and largest spills that occur in the waterway system.

II. PROJECT DESCRIPTION

Objectives

2.01 Current proposals to extend the navigation season in the Great Lakes present the possibility of increased risk of spills of oil and hazardous substances. The objective of this study is to determine the probability of a hazardous substance spill in the St. Clair/Detroit River System as a result of navigation in both winter and non-winter periods. Specifically, the project develops estimates of:

- The numerical probability of a spill occurring on the St. Clair/Detroit River System
- The probable type and magnitude of such a spill.

These estimates are calculated for both winter and non-winter periods for each of the following shipping seasons:

- 1 April to 15 December
- 1 April to 15 January
- 1 April to 14 February
- 25 March to 15 December
- 18 March to 15 December
- Year-Round

2.02 Data gathered and estimated for these seasons are for average ice conditions. Estimates are based on:

- The number of transits of ships carrying petroleum products or hazardous substances in the area
- The number of accidents that can be expected during the transits
- The chance that a spill may occur as a result of an accident
- The likely size of the spill.

Development of Study Analysis

2.03 The St. Clair River, Lake St. Clair, and the Detroit River serve as an avenue for the flow of shipping from the ports of Lake Superior, Lake Michigan, and Lake Huron to Lake Erie, Lake Ontario, and the St. Lawrence Seaway System. Because of this function, the standard measure of vessel activity in the area is the transit or passage of a vessel into or through the waterway.

2.04 This characteristic of vessel activity in the area establishes the way in which the analysis is performed. That is, vessel accident and spill experience will be related to vessel transits in the system. This is fortunate because all of the data required for the computations come from records of discrete events, which eliminates many potential problems in the analysis. The general way that the analysis is performed is as follows:

- Ship Transits through the area are obtained from existing records. Transits of tank ships are separated out from total transits because of the increased hazard of a spill from tank ships.

- Vessel accidents in the area are tabulated from Coast Guard records.

- The probability of an accident on a single transit is obtained by dividing the number of accidents by the number of transits.

- The probability of an accident for a specified number of transits is computed using a special mathematical model. The result of this computation is predictive. That is, it predicts the number of accidents that would occur in an extended season period based on the number of transits that are estimated to occur during that season.

- Vessel spills in the area are obtained from Coast Guard records.

- The probability of a spill given an accident has occurred is computed by dividing the number of spills by the number of accidents.

- The probability of a spill for a specified navigation season is the product of the probability of a spill, given an accident has occurred, and the probability of an accident computed for the desired extended season alternative.

2.05 The probability of a spill is the final computational requirement. To relate accident experience to weather conditions in the normal navigation season and in proposed season extension alternatives, the probability of an accident is computed for both good visibility conditions and low visibility conditions. Also, accidents that could result in spills are arranged according to categories: groundings, collisions, collisions with ice, and groundings in ice . The model is used to compute the probability of a spill in each of these conditions. In addition, an estimate is made of the likely spill size for each of the accident types.

2.06 Obtaining ship transit data for the Detroit River and the St. Clair River is the key element in performing this analysis. Fleet operators using this waterway system report the movement of their vessels to the Corps of Engineers Waterborne Commerce Statistics Center, New Orleans, Louisiana. These records of annual vessel transits are published in "Waterborne Commerce of the United States." To predict the probability of an accident and a spill for the proposed extended seasons, it is necessary to determine monthly vessel transits. ARCTEC, Incorporated therefore obtained a contract with the Waterborne Commerce Statistics Center to perform a special set of computer runs to determine monthly vessel transits for the period 1974 through 1979.

2.07 Transit data obtained from the Statistics Center include records of the movement of U.S. vessels in the system. Records of transits of Canadian vessels in the system were obtained from the Canadian Coast Guard Traffic Center located at Sarnia, Ontario. The Canadian data are for the St. Clair River for the years 1979 through 1981. Only a general estimate of recent Canadian accident and spill experience was available, therefore the Canadian records are only presented as background information.

2.08 In this study, transit records and accident records are used to compute the probability of an accident on a single transit. A mathematical model is then used to compute the probability an accident will occur within the number of transits planned for a specific extended season period. To make this prediction, it is necessary to estimate the number of vessel transits that would occur during these seasons. Estimates of the number of transits that would occur in these seasons are based on fleet operators predictions of the extent to which they would expand their operations if the Coast Guard provided additional icebreaker support.

2.09 Records of vessel accident experience is also related to the weather conditions in which they occur so that a separate probability can be determined for accidents in good visibility conditions and accidents in reduced visibility conditions. Using these values, the probability of an accident is computed according to visibility conditions for the extended season options by knowing the average number of days that low visibility occurs during these seasons. This refinement improves the accuracy of predicting casualties during the proposed extended season periods. Historic records of visibility conditions were obtained from NOAA Local Climatological Data for the St. Clair River and the Detroit River. These records were used to determine the percent transits that occurred in low visibility and the percent that occurred in good visibility.

2.10 The results of the statistical analysis are supplemented by an operational assessment of likely accident situations that could occur during extended season operations. This assessment was developed through interviews with the Coast Guard officers who are responsible for safe navigation in the St. Clair River and the Detroit River. For this analysis, interviews were obtained with the Chief of Operations, 9th Coast Guard District, Cleveland, Ohio; the Director of the Great Lakes Pilotage Staff; the Captain of the Port, Detroit; and the Commander, Coast Guard Group Headquarters, Detroit. This operational assessment is used to verify and confirm the results of the statistical analysis.

III. DESCRIPTION OF THE ST. CLAIR/DETROIT RIVER WATERWAY SYSTEM

Physical Characteristics

3.01 The St. Clair River is the upper portion of the St. Clair/Detroit River System that extends from Lake Huron to Lake Erie. The river itself extends from Lake Huron to Lake St. Clair, as shown in Figure III-1. The St. Clair River is divided into a 28 mile upper section and an 11 mile lower delta section, commonly called the St. Clair Flats (1). A navigation channel runs through the length of the river and along the South Channel in the delta (2).

3.02 Lake St. Clair is a shallow basin that serves as a connecting waterway between the Detroit and the St. Clair Rivers. The maximum natural depth of the lake is 21 feet and the average depth is about 11 feet. Because of depth restrictions, Lake St. Clair has no commercial harbors. There is a single navigation channel dredged to a depth of 27.5 feet and a width of 800 feet that stretches 18.5 miles from the southern end of the St. Clair River to the northern end of the Detroit River (2).

3.03 The Detroit River is the lowest portion of the system, extending a distance of about 32 miles from Lake St. Clair to Lake Erie. In the northerly section of the River from Lake St. Clair to the head of Fighting Island, a distance of about 13 miles, the river is generally deep and the channel banks are quite steep. The southerly or lower river is broad and is marked by many islands and shallow areas. In this section the banks are more flatly sloping than in the upper river and the bottom consists generally of earth, bedrock, and boulders. Extensive rock excavation and dredging have been needed in this area to provide channels of suitable width and depth for large vessels. Navigation channels greater than 27 feet and varying in width from 600 to 1200 feet are maintained through the Detroit River to deep water in Lake Erie. In the lower section the Amherstburg and Livingstone Channels provide parallel navigation channels (2).

Channel Restrictions

3.04 Structures - There are two bridges crossing the St. Clair/Detroit River System, the Blue Water Bridge over the St. Clair River and the Ambassador Bridge over the Detroit River.

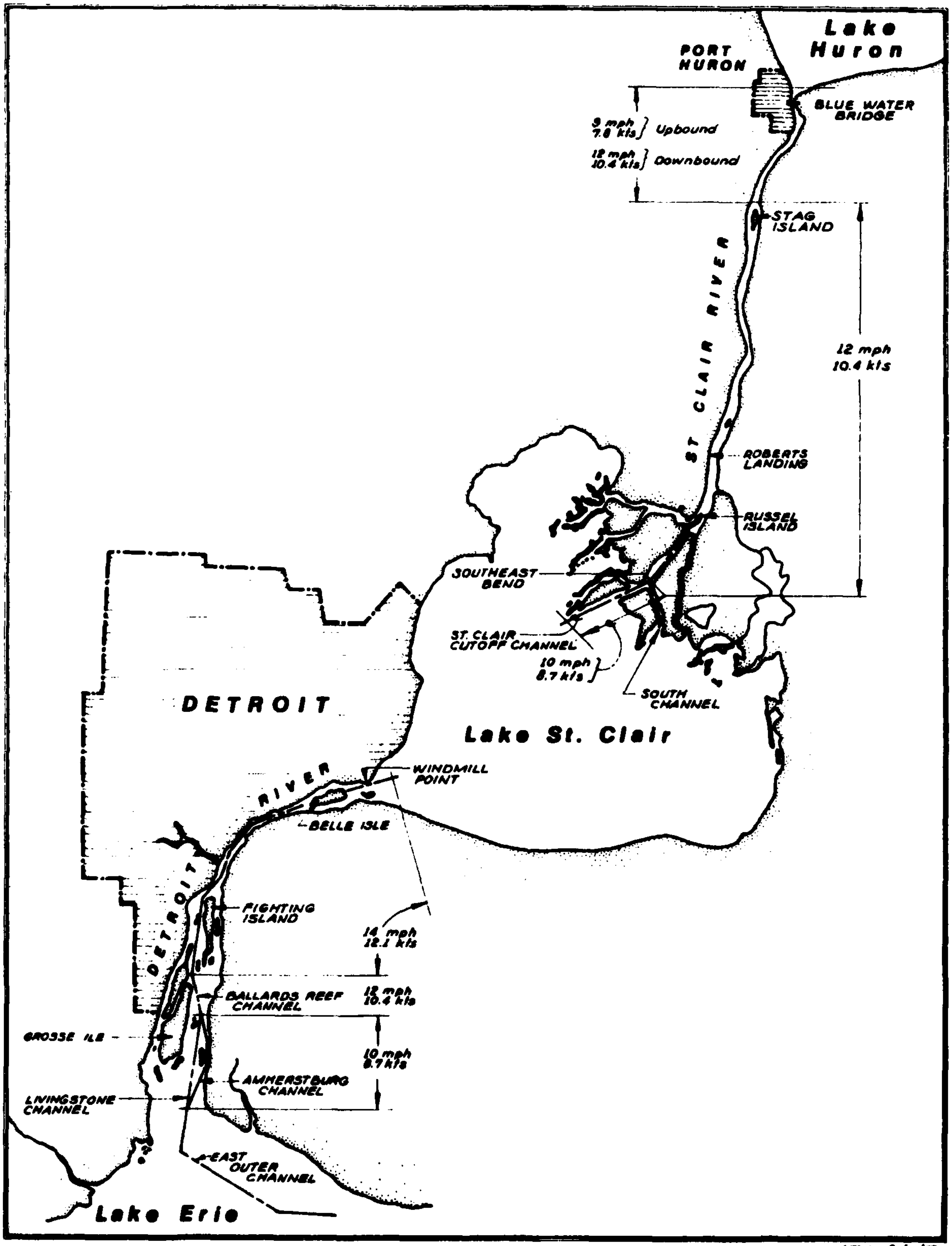


FIGURE III-1 ST. CLAIR - DETROIT RIVER SYSTEM - PRINCIPAL AREAS AND SPEED LIMITS

Vertical clearances range from 133 feet to 156 feet while the clear width range is from 100 to 600 feet. Two tunnels cross under the channel in the Detroit River with depths at mid-channel of 31 feet and 40 feet. Other obstructions crossing the channel include three aerial cables, seven submerged cables, and eight submerged gas, water, and oil pipelines (2).

3.05 Navigational Hazards and Speed Limits - A bend in a channel that is not a navigation problem for a single vessel can be a problem for two vessels passing. There are three areas on the St. Clair/Detroit River System that have this problem. Two are on the St. Clair River; Southeast Bend and Blue Water Bridge. Blue Water Bridge is restricted to one-way traffic although it has a clear span width of 600 feet. The other spot is in the lower Amherstburg Channel in the Detroit River. These areas and speed limits are shown in Figure III-1.

Ice Conditions

3.06 Ice can be expected to be a winter hazard to navigation in the St. Clair/Detroit River System (3). Lake St. Clair freezes over and remains frozen most of the winter, but the St.Clair River and the Detroit River generally remain clear because of high currents. Some sections of these rivers may have ice jams caused by ice entering from adjacent lakes; however, these jams can be opened using icebreakers and high currents will quickly carry the ice away (4).

3.07 Ice accumulations begin in the southern section of Lake Huron at the entrance to the St. Clair River. During freezeup ice jams in the narrow section of the channel and can slow or stop navigation until the ice stabilizes and becomes shorefast. At freezeup brash ice may fill the channel to the bottom so that even icebreakers could not push through. Once the ice freezes to the shoreline, ships can generally pass (5).

3.08 During breakup large amounts of drifting ice may become concentrated at the entrance to the St. Clair River near Port Huron. Broken ice from Lake Huron also jams in the lower St. Clair River. When the ice floes reach the vicinity of Russell Island, jamming develops and the jam may advance upstream. The build-up of ice jams result in increased water levels upstream and lower water levels downstream of the jam. Flooding at the southern end of the St. Clair River is generally related to ice jams (1). Although the St. Clair River may have seasonal ice jams, it does not generally freeze over (6). Icebreaker assistance would only be required occasionally to break ice jams for season extension.

3.09 Lake St. Clair is shallow and therefore reacts quickly to wind conditions and temperature changes to form ice. Ice accumulates faster in the eastern half of the lake, which usually becomes ice covered by the end of January. During the period of greatest ice cover there is thick, fast ice in the bays and protected areas, and heavy, consolidated floes of brash and cake ice in the midlake shipping channel (3). The stability of the ice cover in Lake St. Clair is very sensitive to wind direction and velocity. Vessel tracks in the lake can be closed by winds soon after a vessel passes. Since the ice moves, the cut channel can also move. This may present a problem because there is only one fixed aid to navigation in Lake St. Clair. Also, when a vessel track is maintained in an area, the process of freezing and breakup of ice in the vessel track caused by the passage of vessels results in the build-up of brash ice. This ice can develop to depths of 2 to 10 feet (1).

3.10 The area of Lake St. Clair at the head of the Detroit River is usually ice-free during the entire season except for minor jamming when drift ice becomes concentrated in the area. Breakup on Lake St. Clair occurs quickly. As the ice begins to melt, winds and currents move the drifting ice to the entrance of the Detroit River where strong currrents move it downstream. The lake is usually ice-free in early March.

3.11 The lower section of the Detroit River sometimes freezes over; however, in the upper river thermal discharges from industry generally help to maintain open water. Ice from Lake St. Clair may cause ice jams in both the upper and lower sections of the Detroit River; however, if the ice remains in Lake St.Clair, the Detroit River generally remains clear (7).

3.12 Winter ice conditions in the area can be summarized as follows (1):

- Southern Lake Huron: Ice cover usually grows to 18 to 24 inches in Southern Lake Huron. When an ice bridge forms in the vicinity of Fort Gratiot, the ice cover is stabilized. Otherwise the ice is discharged into the St. Clair River.

- St. Clair River: The St. Clair River does not usually develop significant ice cover. Ice cover in the delta area accumulates upstream into the lower St. Clair River when large volumes of ice are discharged from Lake Huron.

- Lake St. Clair and St. Clair Delta: These areas usually develop a stable ice cover. Icebreaking is necessary to maintain vessel tracks. The extent of stable cover in the delta area depends upon the amount of ice that moves down from Lake Huron.

- Upper Detroit River: This section does not generally develop a stable ice cover although ice jams may occur when ice comes down out of Lake St. Clair.

- Lower Deroit River: Ice cover may develop from Fighting Island downstream and could require icebreaking to maintain navigation for coal ships operating between Lake Erie and Detroit.

- Western Lake Erie: Ice cover generally develops to 18 inches in this area. Wind conditions can develop ice pressure ridges 5 to 10 feet high and several hundred feet long.

3.13 Water Levels - High winds may change the water level in the St. Clair River by 2 feet in a short time. In the Detroit River the water level may change as much as 6 feet in 8 hours (2). South winds increase the depth in the Detroit River, but north and west winds move the water down to Lake Erie and lower the water level in the Detroit River (5). Water level changes in Lake St. Clair are more moderate since it generally takes several hours for a change of 1 foot to occur. Fluctuations of water level may result in available water levels in channels being less than charted depths. Low water warnings are transmitted periodically by radio. When water levels are low, heavily laden vessels must anchor and wait for the depth to increase. The controlling depth of the system is 27.1 feet. Figure III-2 shows project depths for the St. Clair/Detroit River System (8).

NOTE:

AMHERSTBURG CHANNEL

In middle and lower section depths shown are for westerly width of 300 ft., easterly width has 21 ft. project depth. In upper section depths are for full 600 ft. width. Easterly 21.0 ft. of project has scattered shoals at 21.8 ft. depth.

[A] Livingstone Channel - Construction completed. However, in the dike section, upper channel, scattered shoals, and bedrock projections exist to a depth of 26.7 feet below LWD.

[B] Vessel masters should refer to Local Notice to Mariners for extent of shoaling.

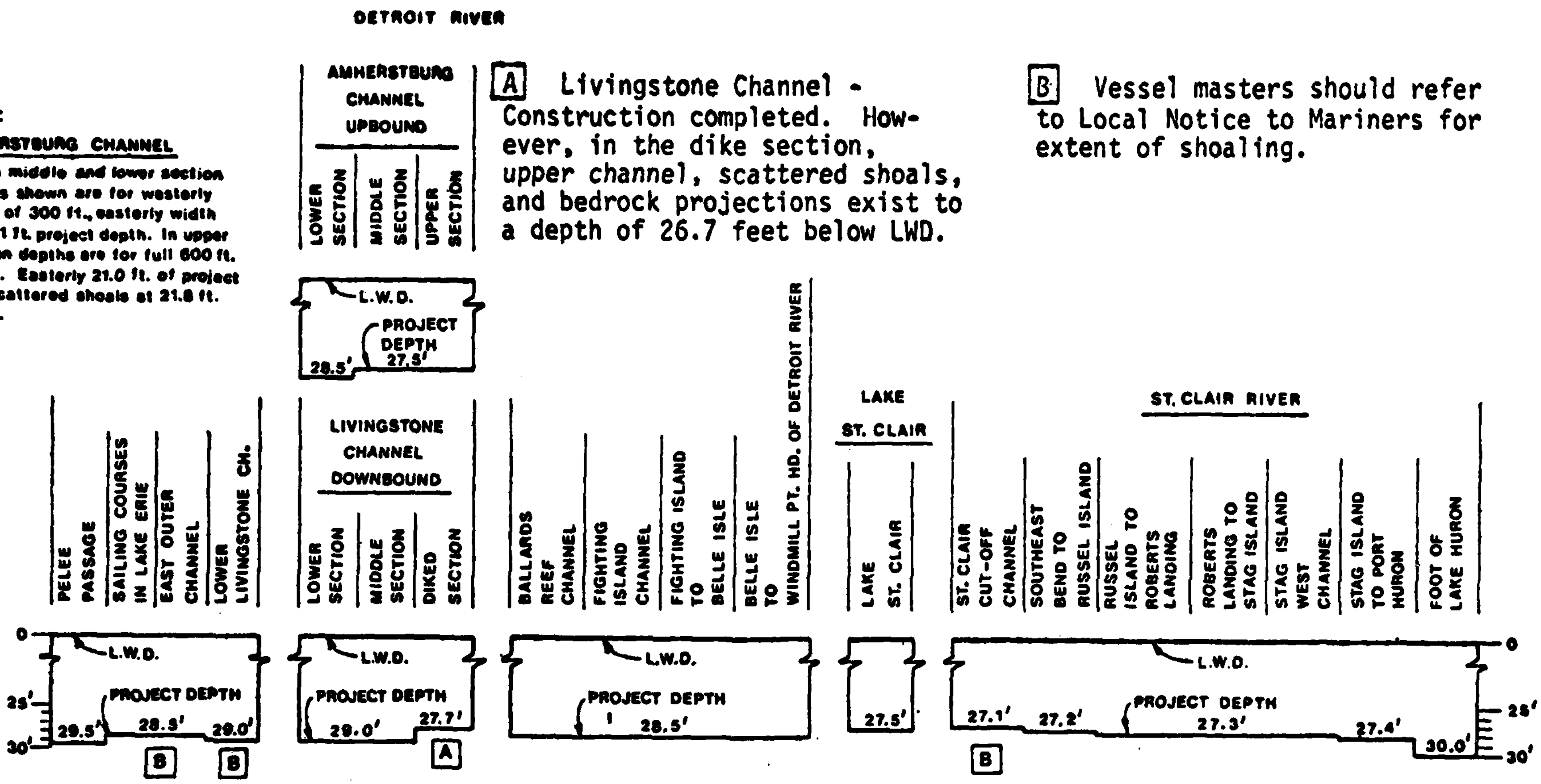


FIGURE III-2 PROJECT DEPTHS IN THE ST. CLAIR - DETROIT RIVER SYSTEM (8)

The connecting channels as authorized provide depths varying from 27 to 30 ft below LWD, depending on exposure of channel, hardness of bottom material, and vessel squat in each reach.

Chart hereon is for information only. These depths are designed to permit maximum draft of 25-1/2 ft for lake vessels when the water level is at LWD. However, the individual vessel Master should give further consideration to the peculiar characteristics of his vessel and to his individual clearance and safety requirements in determining the safe draft to which to load his vessel.

3.14 Current Velocities - The St. Clair River is a high current stream with maximum midstream current velocities of 5.7 mph in the rapids section under the Blue Water Bridge and 2 mph in the Southeast Bend in the lower section of the river. The Detroit River has maximum midstream current velocities of 1.8 mph adjacent to Belle Isle and 3 mph in the Livingston Channel in the lower section of the river (2).

IV. OPERATIONAL ASSESSMENT OF ACCIDENT AND SPILL POTENTIAL

Background

4.01 This study is primarily a statistical analysis of the probability of a spill of a hazardous substance in the St. Clair/Detroit River System. Records of ship casualties and spills are used to determine the probability and frequency of these events. Accident records and statistical information cannot be used alone, however. The assessment of hazards to navigation must also be based on the judgment of experienced mariners who operate in the area. There are several reasons why this is true. First, the accident frequency in this area is relatively low, particularly for tankers. This means that available records may not provide an adequate data base for good statistical results. Second, the probability of an accident and a spill is dependent on a great many variables. These variables include a number of non-statistical parameters such as natural hazards to navigation and fleet operating patterns. Because it is difficult to establish a numerical measure of effectiveness for these parameters, prediction of trends in vessel casualties must be based on the judgment of experienced mariners as well as the records of past performance.

4.02 This section presents an operational assessment of the hazards of operating in the St. Clair/Detroit River area beyond the limits of the traditional season, assumed for this study to be 1 April to 15 December. Emphasis, therefore, is on operating in ice and other winter hazards to navigation. This operational assessment has been developed by interviewing senior officials in the agencies responsible for operations in this system. Some of the individuals and agencies contacted include the Chief of Operations, 9th Coast Guard District, Cleveland; Captain of the Port, Detroit; the Director of the Great Lakes Pilotage Staff; and Coast Guard Group Headquarters, Detroit. Several other agencies and individuals were also interviewed. These sources can be identified in the footnotes in the sections that follow. The operational assessment of accident and spill potential is divided into sections according to the hazards or problems involved, such as aids to navigation, control of shipping, ice, and so forth.

Aids to Navigation

4.03 Channel buoys, fixed lights, and ranges are the principal aids to navigation in the St. Clair/Detroit River System. In winter all of the regular lighted channel buoys are pulled because of the ice conditions (5). Radar buoys and lighted ice buoys are installed on the turns in the winter and there are plans for additional permanent lighted structures. There is a single fixed lighted structure in the center of Lake St. Clair which, of course, is available all year. There is a range marking the approach to the Detroit River that can be seen all the way across the lake when visibility is good (6). Having buoys removed in winter does not cause a severe limitation to navigation. For example, in the Detroit River traffic continues between Detroit and Windsor, Ontario all winter with no problems because the buoys are out (6).

4.04 Navigating the long channel across Lake St. Clair does present some problems when buoys are removed for the winter (9). Upbound, mariners sight on the Peach (Peche) Island Range astern (at the head of the Detroit River) to stay in the channel. The fixed Lake St. Clair Light marks the center of the lake and a slight left turn as the channel continues to the St. Clair River. This turn is about 11 miles from the Peach Island Range and 8 miles from the next range ahead marking the channel to the St. Clair River. When visibility conditions are low, these navigation aids are likely to be obscured. Ships may either stray out of the channel because of reduced visibility, or they may be forced out of the channel by shifting ice fields. Fortunately, the bottom adjacent to the channel is soft mud so that a grounding in Lake St. Clair is not likely to cause a spill. The Coast Guard is considering installation of RACON units at both the ranges. These devices receive the pulse of energy from the ship's radar and return a coded signal so that they can be positively identified. When visibility is low, a bearing on the RACON can be used instead of sighting on the range.

4.05 There are some changes in operating procedures during winter operations, however. The Ford Motor Company often operates ships hauling coal between Toledo and their River Rouge Plant in the Detroit River for eleven months of the year (7). After the channel buoys have been removed they use radar and fixed ranges for navigation and operate in daylight hours only. If ice conditions become too severe, they discontinue operations. There are also changes in traffic patterns in the winter. The Canadian Amherstburg Channel in the southern section of the Detroit River is closed for the winter which means that both downbound and upbound traffic must use the Livingstone Channel. This narrow channel then becomes a one-way traffic zone and is controlled by the Traffic Center at Sarnia (5).

4.06 The entrance to the Detroit River from Lake Erie in the south can be a problem in any season because the high winds and currents often move the channel buoys out of position (5).

Control of Shipping

4.07 In some areas traffic is controlled by the Canadian Coast Guard Traffic Center located at the entrance to the St. Clair River in Sarnia, Ontario (9). Traffic is monitored by ships calling into the Traffic Center by radio. The rapids under the Blue Water Bridge between Sarnia and Port Huron, Michigan is a primary control area. Because of the narrow channel and currents up to 6 knots, this section of the channel is limited to one-way traffic. Downbound traffic has the right-of-way and vessel movements are controlled by radio from Sarnia. At the southern end of the Detroit River there is one-way traffic in the Livingstone Channel in the winter. This section is also controlled by Sarnia.

4.08 Vessels are advised of potential hazards to navigation in storm warnings and low water warnings. As an example of the kinds of warnings that are issued, a south wind increases the depth in the Detroit River and a north or west wind moves the water down to Lake Erie and lowers the water level in the Detroit River (5). If the water depth is reduced appreciably, heavily laden vessels must anchor and wait for the depth to increase. These kinds of warnings are passed as Notices to Mariners by radio. Visibility warnings are also issued, but there are no special criteria for closing the river to navigation because of low visibility (10). Vessels are equipped with radar and are expected to proceed cautiously. The Captain of the Port in Detroit has the facilities to control vessel traffic in the river if it is required because of low visibility or other hazards to navigation.

Ice Conditions

4.09 Section III of this study contains a summary of ice conditions based on National Oceanic and Atmospheric

Administration (NOAA) reports, other studies, and to some extent reports of local operators (11, 12) . In this section the description of ice conditions is based entirely on interviews with local fleet operators. Although some of the fleet operator information is repeated from Section III, this section is complete in itself in that it provides all of the information obtained from interviews with local authorities and operators.

4.10 Coast Guard officers and fleet operators both report that the Detroit and St. Clair Rivers are generally ice-free in the winter because of the high currents that occur in the area (4, 6). But there are exceptions to this general observation. During the winter of 1980-81 the Detroit River was jammed with ice from Fighting Island north for the entire season (4). There were also ice jams south in the Livingstone Channel area. All of these ice obstructions were caused by ice jams, not freeze-over. If there had been a requirement to move vessel traffic in the area, the ice jams could have been opened with a Coast Guard or commercial icebreaker. Coast Guard observers believe that once the jam was broken, the high currents would have quickly carried it away.

4.11 At the northern end of the waterway system, ice often jams in the narrow channel under the Blue Water Bridge before it sets up and becomes shorefast (5). This condition can make operating during the freeze up period in January a problem. Brash ice sometimes fills the channel to the bottom. Even icebreakers cannot make it through this accumulation when it becomes 20 feet thick. Once the ice freezes to the shoreline, the brash ice is generally carried away and navigation can resume.

4.12 Later in the year an ice bridge forms at the Blue Water Bridge. If the ice bridge breaks up, ice is released and is likely to jam downstream in the St. Clair River Delta. Normally the ice bridge holds the ice in place. As long as the bridge is maintained, navigation can continue (9).

4.13 Ice jams are often a problem in the southern end of the St. Clair River approaching the Delta. These jams occur at Harsens Island and also at the Southeast Bend (9). The shipping channels in the St. Clair River Delta do not clear of ice easily because they only carry about 30% of the flow of the river (13). The North Channel has most of the natural flow of water, but the shipping traffic now uses the dredged Cutoff Channel to the south.

4.14 Ice in Lake St. Clair can also be a problem. The lake generally freezes over completely and a shipping channel is cut in the ice. The problem is that the ice may shift which means that the channel cut in the ice also moves (5). This could result in a vessel grounding.

4.15 Fleet operators report that the Detroit River does not usually freeze over but just collects ice floes (6). A petroleum barge operator reports that they regularly make winter trips from Buffalo to Detroit and also from Sarnia to Detroit. These barges operate in frozen rubble of variable thickness. Navigation is a particular problem in the St. Clair River Delta because the ice accumulations may be 6 to 8 feet thick. It is possible to push through these ice accumulations, but just barely. Operators use two tugs in these situations; one tug ahead to break the ice and one astern to push the barge. The operator reports that they have never had a hole in a barge caused by a collision with ice but their barges have been dented by ice without rupturing the hull.

4.16 A barge operator also reports that the St. Clair River does not freeze over in the winter (6). This operator sometimes continues runs with Number 6 fuel from Marysville to Sarnia on the St. Clair River all winter.

4.17 Coast Guard officials report that the Detroit River is likely to have some ice cover from Fighting Island south in late winter. Ice jams can be expected and rafted ice may be 10 inches thick.

4.18 In the southern section of the Detroit River, there are problems with ice jams in the narrow channel at Ballards Reef and in the Livingstone Channel (13). Winds from the south keep the ice in place in these channels, but when winds shift, the ice is flushed out.

4.19 The Ford Motor Company generally transports coal between Toledo and their River Rouge Plant in the southern section of the Detroit River eleven months out of the year (7). The Marine Operations Manager reports that in a mild winter, the river is clear. Sometimes the river becomes clogged with brash ice at freezeup. If this ice remains in Lake St. Clair, the Detroit River remains clear. If it descends, then there is a problem. Sometimes the Livingstone Channel freezes up so that ships become beset by ice and require icebreaker assistance. Ford has one ship with a strengthened bow for operating in ice. Ice damage may not only occur in the bow, however. Ice damage may also occur farther aft when the ship is in turns. Ford has found that a ship's quarter may be damaged by swinging against 3 feet of ice in turns.

<u>General Operational Assessment</u>

4.20 Captain Gordon Hall, Chief of Operations, 9th Coast Guard District, believes that winter navigation in the St. Clair/ Detroit River System would not result in more accidents (13). In earlier years there were some accidents at the Blue Water Bridge, but there have not been any accidents since one-way traffic was instituted in 1972 (9). Captain Hall does not believe there is much problem with ice shifting in Lake St. Clair. His experience has been that once the ice sets up it says in place. In addition, if a ship does stray out of the channel, there is not much danger of a hull rupture because she will go aground in mud. The Coast Guard is adding a new range at the southern end of Lake St. Clair which should help solve navigation problems. The deep water channel extends nearly bank-to-bank in the St. Clair River and if a ship leaves the channel it will only contact mud.

4.21 Ice conditons are much less severe in the St. Clair/ Detroit River System than in other areas of the Great Lakes such as the St. Marys River. The southern end of the St. Clair River sometimes has ice jams formed by a pile-up of ice pieces 2 to 3 inches thick. This can produce a mass of ice that will restrict ship passage, but it is not likely to hole a ship and cause an oil spill.

4.22 The overall assessment, then, is that winter operations in the St. Clair/Detroit River System can be expected to be relatively safe. Navigation procedures may be somewhat different in winter because many buoys are removed, but radar buoys are added at the turns and ranges are available, so that navigation is generally not considered to be more hazardous. Some fleet operators compensate for these differences by only operating during daylight in the winter.

4.23 Ice conditions in the St. Clair/Detroit River System may make navigation somewhat more difficult in the winter, but operations can continue and there is very little danger of holing a ship because of a collision with ice. Ice conditions can be best characterized by ice jams and accumulations of slush that may extend nearly to the bottom of the channel. Ice jams can generally be cleared by icebreakers, and although accumulations of slush ice may temporarily stop navigation completely, the slush clears quickly when strong currents flush out the ice.

4.24 In the opinion of responsible Coast Guard officials and fleet operators, winter operations in the St. Clair/Detroit River System are only slightly more hazardous than normal season operations and winter ice does not present a special danger to spills of hazardous substances.

V. PROFILE OF HAZARDOUS SUBSTANCES TRANSPORTED THROUGH THE ST. CLAIR/DETROIT RIVER SYSTEM

5.01 Tables V-1 through V-3 show the petroleum and hazardous substances transported through the St. Clair/Detroit River System for the period 1974 through 1979 (14). These records cover commodities carried between U.S. ports or between U.S. and Canadian ports. They do not include commodities moving in the system between Canadian ports. The tables show that the petroleum products are principally refined fuels, mostly gasoline and distillate fuel oil, and in recent years, increasing amounts of residual fuel (number 6) moving in the St. Clair River. Hazardous substances are mostly basic chemicals that generally are not likely to spill as a result of a vessel accident. Benzene and toluene present the threat of a toxic spill, but these substances make up less than 10% of the volumes of petroleum products that are shipped. Tables summarizing spills in the next section show that there have been no spills of benzene or toluene in any part of the St. Clair/Detroit River System for the period 1974 through 1979, therefore the probability of a spill of these substances resulting from an accident must be considered to be very small.

5.02 The reader will also notice that most of the entries in Tables V-1 and V-2 for the St. Clair River and Lake St. Clair are the same. This is because Lake St. Clair has a dredged channel with no ports and is therefore considered an extension of the St. Clair River.

5.03 Tables V-4 and V-5 show the average annual shipments of petroleum products and hazardous substances for the years 1974 through 1979. A summary for Lake St. Clair is not shown because it is similar to the St. Clair River.

5.04 Table V-4 shows that crude petroleum is only 4% of the total of petroleum products shipped in the St. Clair River. This indicates that the probability of a spill of crude petroleum is likely to be very small. Distillate fuels including gasoline, jet fuel, kerosene, and fuel oil, make up 33% of total fuels shipped. Residual fuel oil (also called number 6 and Bunker C) is 49% of the total amount of petroleum products shipped. This commercial fuel is transported to the several electrical power plants located along the St. Clair

TABLE V-1 PETROLEUM AND HAZARDOUS SUBSTANCES TRANSPORTED VIA THE ST. CLAIR RIVER BY COMMODITY, 1974-1979 (14)
(SHORT TONS)

COMMODITY	1974 UPBOUND	1974 DOWNBOUND	1975 UPBOUND	1975 DOWNBOUND	1976 UPBOUND	1976 DOWNBOUND	1977 UPBOUND	1977 DOWNBOUND	1978 UPBOUND	1978 DOWNBOUND	1979 UPBOUND	1979 DOWNBOUND
PETROLEUM PRODUCTS												
Crude Petroleum	15,981		26,748	8,601	102,341	7,508	23,136			13,445		
Crude Tar, Oil & Gas Products				5,046	2,748	471	5,163	349	6,760		5,976	16
Gasoline	107,878		113,967	87,591	94,743	20,350	33,508	18,210	138,915	9,254	31,630	3,053
Jet Fuel	27,521										19,691	
Kerosene	6,019		7,824	9,822	5,557	94				85		
Distillate Fuel Oil	116,801	66,889	73,952	118,714	42,720	95,813	36,731	85,311	95,818	6,779	51,213	7,165
Residual Fuel Oil	65,535	127,509	79,414	125,764		134,569	339,561	349,537	329,567	121,845	495,127	165,940
Lube Oil and Grease	21	62	2	377		198	9	13,499	36,559	1,282	43,454	12,730
Naptha, Solvents, NEC*										10,045		
Asphalt, Tar, Pitches			25,375		68,212		43,104		96,451	79,860	77,701	117,826
TOTAL	339,756	194,460	327,282	355,915	316,321	259,003	481,212	466,906	704,070	242,595	724,792	306,730
HAZARDOUS SUBSTANCES												
Sodium Hydroxide			7,545									
Dyes and Tanning Materials	898	189	138	40	170	76	826	64		70		26
Radioactive Wastes	165								2,175		2,067	
Benzene and Toluene	21,578		22,128		27,736		49,060	1,594	23,736		51,841	
Basic Chemicals, NEC*	153,258	39,274	62,201	20,368	69,487	25,657	118,294	29,768	158,572	135,960	197,547	168,961
Paints, Lacquers, Varnishes	3	109	23	144	31	341	93	251	89	1,278	2,436	3,149
Insecticides and Disinfectants	8	1,728	40	1,322	243	451	19	8	387	716	25	868
Misc. Chemical Prducts	3,609	4,231	1,379	4,988	822	8,727	14,687	5,360	12,743	18,774	21,374	22,268
TOTAL	179,519	45,531	93,454	26,862	98,489	35,252	182,979	37,045	197,702	156,798	275,290	195,272

* Not elsewhere classified.

TABLE V-2 PETROLEUM AND HAZARDOUS SUBSTANCES TRANSPORTED VIA LAKE ST. CLAIR BY COMMODITY, 1974-1979 (14)
(SHORT TONS)

COMMODITY	1974		1975		1976		1977		1978		1979	
	UPBOUND	DOWNBOUND	UPBOUND	DOWNBOUND	UPBOUND	DOWNBOUND	UPBOUND	DOWNBOUND	UPBOUND	DOWNBOUND	UPBOUND	DOWNBOUND
PETROLEUM PRODUCTS												
Crude Petroleum			13,523	8,601	83,652	7,508				13,445		
Crude Tar, Oil & Gas Products				5,046	2,748	471	5,163	349	6,760		5,976	16
Gasoline	107,878		90,741	87,591	56,448	20,350	33,508	18,210	98,118	4,480	31,630	18
Jet Fuel	27,521										19,691	
Kerosene	6,019		7,824	9,822	5,557	94				85		
Distillate Fuel Oil	111,326	66,889	73,952	118,714	42,720	95,813	33,652	85,311	95,818	6,779	51,213	7,165
Residual Fuel Oil	51,749	123,400	79,414	125,764		134,569	52,102	349,537	72,573	121,845	100,461	165,940
Lube Oil and Grease	21	62	2	377		198	9	13,499	36,246	328	43,338	11,371
Naptha, Solvents, NEC*										10,045		
Asphalt, Tar, Pitches			25,375		68,212		43,104		96,451	79,785	77,701	117,760
TOTAL	304,514	190,351	290,831	355,915	259,337	259,003	167,538	466,906	405,966	236,792	330,010	302,270
HAZARDOUS SUBSTANCES												
Sodium Hydroxide			7,545									
Dyes and Tanning Materials	898	189	138	40	170	76	826	64		43		3
Radioactive Wastes	165								2,175		2,067	
Benzene and Toluene	21,578		22,128		27,736		49,060	1,594	23,736		51,841	
Basic Chemicals, NEC*	70,372	39,274	37,082	20,368	30,645	25,657	26,889	29,768	33,698	39,531	32,229	42,629
Paints, Lacquers, Varnishes	3	109	23	144	31	341	93	251	89	400	2,436	128
Insecticides and Disinfectants	8	1,728	40	1,322	243	451	19	8	387	21	25	35
Misc. Chemical Products	3,609	4,231	1,379	4,988	822	8,727	5,830	5,360	2,121	4,102	2,504	3,389
TOTAL	96,633	45,531	68,335	26,862	59,647	35,252	82,717	37,045	62,206	44,097	91,102	46,184

* Not elsewhere classified.

TABLE V-3 PETROLEUM AND HAZARDOUS SUBSTANCES TRANSPORTED VIA THE DETROIT RIVER BY COMMODITY, 1974-1979 (14)
(SHORT TONS)

COMMODITY	1974		1975		1976		1977		1978		1979	
	UPBOUND	DOWNBOUND	UPBOUND	DOWNBOUND	UPBOUND	DOWNBOUND	UPBOUND	DOWNBOUND	UPBOUND	DOWNBOUND	UPBOUND	DOWNBOUND
PETROLEUM PRODUCTS												
Crude Petroleum			13,523	8,601	152,264	12,310	14,421			13,445		
Crude Tar, Oil & Gas Products	144,964		138,412	5,046	139,748	2,487	136,476	349	76,977		6,121	16
Gasoline	112,003	2,471	90,741	97,938	56,448	30,675	33,508	33,552	102,836	4,480	31,630	127
Jet Fuel	27,521										19,691	
Kerosene	8,978		7,824	9,822	5,557	94				85		
Distillate Fuel Oil	252,001	80,314	521,612	149,690	671,221	144,286	78,383	94,431	138,199	49,394	80,860	21,593
Residual Fuel Oil	411,732	168,464	332,726	144,581	308,393	188,031	658,758	399,387	1,113,042	183,412	690,990	264,300
Lube Oil and Grease	57,053	82	60,328	421	79,992	305	77,483	18,683	103,588	543	102,810	11,762
Naptha, Solvents, NEC*									1,821	10,045	1,187	
Asphalt, Tar, Pitches		47,248	25,375	43,225	68,212	48,480	48,304	92,188	101,852	150,720	83,423	193,177
TOTAL	1,014,252	298,579	1,190,541	459,324	1,481,835	426,668	1,047,333	638,590	1,638,315	412,124	1,016,712	490,975
HAZARDOUS SUBSTANCES												
Sodium Hydroxide			7,545	7,721				2,641		2,822		
Dyes and Tanning Materials	898	189	138	40	171	188	1,046	182		43		15
Radioactive Wastes	165					20			8,006		7,771	
Benzene and Toluene	21,578		22,128		27,736		49,060	1,594	23,736		51,841	
Basic Chemicals, NEC*	72,073	43,871	40,096	23,875	37,436	33,696	42,755	39,190	41,434	47,845	38,337	51,451
Paints, Lacquers, Varnishes	12	115	45	151	975	429	472	387	96	430	2,687	270
Insecticides and Disinfectants	8	1,929	40	1,322	243	1,131	707	1,396	779	814	723	742
Misc. Chemical Products	5,086	5,218	2,296	5,443	3,046	10,664	8,307	7,701	5,167	6,541	7,202	7,310
TOTAL	99,820	51,322	72,288	38,552	69,607	46,128	102,347	53,091	79,218	58,495	108,561	59,788

*Not elsewhere Classified.

TABLE V-4 PETROLEUM AND HAZARDOUS SUBSTANCE PRODUCT SUMMARY, ST. CLAIR RIVER, 1974 - 1979 (14)

PETROLEUM PRODUCTS

PRODUCT	AVERAGE AMOUNT SHIPPED	PERCENT OF TOTAL
Crude Petroleum	32,960	4
Crude Tar, Oil, & Gas Products	4,422	1
Gasoline	109,850	14
Jet Fuel	7,869	1
Kerosene	4,900	1
Distillate Fuel Oil	132,984	17
Residual Fuel Oil	389,061	49
Lube Oil and Grease	18,032	2
Naptha, Solvent, NEC*	1,674	0
Asphalt Tar, Pitches	84,755	11
TOTAL	786,507	100

HAZARDOUS SUBSTANCES

PRODUCT	AVERAGE AMOUNT SHIPPED	PERCENT OF TOTAL
Sodium Hydroxide	1,285	1
Dyes & Tanning Materials	416	0
Radioactive Wastes	735	0
Benzene & Toluene	32,946	13
Basic Chemicals, NEC*	196,558	77
Paints, Lacquers, Varnishes	1,325	1
Insecticides & Disinfectants	969	0
Misc. Chemical Products	19,827	8
TOTAL	254,061	100

* NEC - Not elsewhere classified.

TABLE V-5 PETROLEUM AND HAZARDOUS SUBSTANCE PRODUCT SUMMARY, DETROIT RIVER, 1974 - 1979 (14)

PETROLEUM PRODUCTS

PRODUCT	AVERAGE AMOUNT SHIPPED	PERCENT OF TOTAL
Crude Petroleum	35,761	2
Crude Tar, Oil, & Gas Products	108,433	7
Gasoline	99,402	7
Jet Fuel	7,869	1
Kerosene	5,393	0
Distillate Fuel Oil	380,331	25
Residual Fuel Oil	643,969	42
Lube Oil and Grease	85,508	6
Naptha, Solvent, NEC*	2,176	0
Asphalt, Tar, Pitches	150,367	10
TOTAL	1,519,209	100

HAZARDOUS SUBSTANCES

PRODUCT	AVERAGE AMOUNT SHIPPED	PERCENT OF TOTAL
Sodium Hydroxide	3,455	2
Dyes & Tanning Materials	485	0
Radioactive Wastes	2,660	2
Benzene & Toluene	32,946	24
Basic Chemicals, NEC*	85,343	61
Paints, Lacquers, Varnishes	1,012	1
Insecticides & Disinfectants	1,639	1
Misc. Chemical Products	12,330	9
TOTAL	139,870	100

* NEC - Not elsewhere classified.

River. Residual fuel oil is not likely to spill in winter because of its high pour point. At low ambient air temperatures, residual fuel is nearly solid and is not likely to leak from a ruptured hull.

5.05 Eighty-five percent of the hazardous substances shipped on the St. Clair River are basic chemicals and miscellaneous chemical products. In many cases, these chemicals are a bulk cargo and not likely to spill in the event of a vessel accident. In addition, many of the chemicals included in these totals are not necessarily hazardous if they are released in the water. Potentially toxic chemicals such as insecticides and disinfectants make up only 0.4% of the chemical and hazardous substances shipped.

5.06 Table V-5 summarizes petroleum product and hazardous substance shipments in the Detroit River. Although the total amount of the products shipped is nearly double that shipped on the St. Clair River, the distribution among the kinds of products is much the same. Crude petroleum makes up only 2% of the products shipped, and distillate fuels are 33% of the total. Residual fuel oil, an industrial fuel, makes up 42% of the total.

5.07 As in the case of the St. Clair River, basic chemicals and other chemical products include 70% of the hazardous substances shipped in the Detroit River. In many cases, these are bulk shipments and often the chemicals are not harmful if they are released in the water. Benzene and toluene make up 24% of the hazardardous substances transported in the Detroit River. These substances do present the threat of a toxic spill; however, there is no history of these substances being spilled in a vessel accident or during loading or transfer operations in the St. Clair/Detroit River System during the period 1974 through 1980. Therefore, the probability of a benzene or toluene spill must be considered to be very low.

5.08 Table V-6 shows a profile of Great Lakes tankers. The first column listing the number of ships in the U.S. and Canadian fleets shows that the Canadian fleet is mostly tank ships and the U.S. fleet is predominately tank barges. Note that the tankers are much smaller than the bulkers. Great Lakes ore carriers range in length from about 630 feet to 1000 feet and draw 26 to 27 feet of water. In contrast, the tankers have an overall length of 200 to 400 feet and draw 12 to 23 feet of water. The U.S. fleet is predominantly tank barges that draw only 12 to 18 feet of water. Tankers are smaller, more maneuverable ships than bulkers and are therefore less likely to have an accident. Since they have a relatively shallow draft, they are less likely to go aground. This helps to reduce the most serious threat of a large spill from a tanker.

TABLE V-6 PROFILE OF GREAT LAKES TANKERS (15)

TANK SHIPS

NATIONALITY	NUMBER OF SHIPS	AVERAGE AGE	AVERAGE LENGTH (FT)	MID-SUMMER DRAFT (FT)	AVERAGE CAPACITY (BARRELS/TONS)
U.S.	9	20	293	17	37,310/5,740
Canadian	32	17	400	23	64,541/9,929
TOTAL	41				
U.S. and Canadian Built in Last 10 Years	U.S. 5 Canadian 8 TOTAL 13		380	22	62,626/9,635

TANK BARGES

NATIONALITY	NUMBER OF SHIPS	AVERAGE AGE	AVERAGE LENGTH (FT)	MID-SUMMER DRAFT (FT)	AVERAGE CAPACITY (BARRELS/TONS)
U.S.	48	21	261	13	32,519/5,003
Canadian	7	13	186	12	11,780/1,812
TOTAL	55				
U.S. and Canadian Built in Last 10 Years	U.S. 9 Canadian 1 TOTAL 10		346 140	18 8	68,611/10,556 7,552/1,162

VI. VESSEL TRANSITS, ACCIDENTS, AND SPILLS

Vessel Transits Through the St. Clair/Detroit River System

6.01 The St. Clair/Detroit River System is a choke point to shipping traffic between the northern three Great Lakes and the ports along the Detroit River, Lake Erie, Lake Ontario, and the St. Lawrence Seaway System to the east. There are some ports along the St. Clair River, but the primary navigational function of this river is to provide a channel for the flow of traffic between Lake Huron, the Detroit River, and Lake Erie. Lake St. Clair is a shallow body of water with a dredged channel running across its center. There are no ports on Lake St. Clair so this section of the system serves only as a connector between the St. Clair River and the Detroit River. Although the Detroit River has many busy commercial ports, it is also primarily a thoroughfare for ships moving through the system. Because the primary navigational function of the St. Clair/Detroit River System is to provide for the flow of traffic between ports of the Great Lakes, the standard measure of vessel activity in the area is the transit or passage of vessels from one end of the system to the other. Vessel transits are used as the measure of shipping activity and provide the basis for computing the probability of vessel accidents and spills in the system. Collecting data for this analysis, then, begins with a tabulation of vessel transits through the three sections of the St. Clair/Detroit River Waterway System.

6.02 Tables VI-1 through VI-3 show transits of ships through each section of the system for the period 1974 through 1980. Since accident data are only available through 1979, the records for only the first six years will be used in the computations. These transit records were obtained from special computer runs provided by the Waterborne Commerce Statistics Center in New Orleans (16). These runs were necessary to obtain transit data by the month since the standard publication of the Statistics Center, "Waterborne Commerce for the United States", only reports vessel transits annually. Vessel trips for calendar years 1977-1978 on Tables VI-1 to VI-3 do not agree with the trip statistics in the publications because these numbers have been updated since the documents were published.

6.03 Table VI-1 shows vessel transits for the St. Clair River. The records are divided into transits of tankers and other vessels. The tanker category includes both tank ships and tank

TABLE VI-1 VESSEL TRANSITS, ST. CLAIR RIVER, 1974 - 1980 (16)

YEAR	1974		1975		1976		1977		1978		1979		1980	
MONTH	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER
JANUARY	31	3,126	77	3,867	61	1,522	47	644	61	1,898	47	1,576	86	4,135
FEBRUARY	40	2,194	62	2,611	61	2,046	41	2,393	53	2,651	49	2,110	30	3,048
MARCH	42	3,398	56	2,974	75	4,330	51	4,391	51	3,485	41	4,412	54	6,233
APRIL	54	5,303	62	4,359	82	5,833	72	4,712	65	4,765	71	5,230	70	2,315
MAY	43	6,122	90	5,765	76	6,128	74	6,105	73	5,600	85	9,113	80	6,056
JUNE	47	6,487	93	6,726	64	6,852	80	6,139	77	5,749	75	3,793	80	6,407
JULY	43	6,721	81	7,346	75	7,425	76	7,327	103	6,285	89	7,095	82	5,894
AUGUST	64	6,820	85	6,373	57	7,043	67	7,207	97	6,066	106	6,992	81	6,893
SEPTEMBER	81	6,414	73	5,864	68	6,310	73	4,830	81	6,469	84	6,535	98	3,002
OCTOBER	63	6,134	85	5,957	83	6,306	58	5,398	73	6,510	79	6,491	99	5,906
NOVEMBER	80	5,417	40	6,480	73	5,748	64	5,054	68	3,253	89	5,570	110	3,097
DECEMBER	80	4,829	49	3,896	62	4,350	68	4,516	69	2,888	104	4,725	31	2,524
ANNUAL*	105	232	66	1,658	25	2,707	25	3,375	19	3,344	23	2,975	-	589
TOTAL	773	63,197	919	63,876	862	66,600	796	62,091	890	58,963	942	66,617	901	56,099
ANNUAL TOTALS	63,970		64,795		67,462		62,887		59,853		67,559		57,000	

Total Tanker Transits 1974 - 1979 = 5,182
Total Other Transits 1974 - 1979 = 381,344

TANKERS - tank ships and tank barges
OTHER - all other commercial vessels

*Annual - some fleets report only once per year.

TABLE VI-2 VESSEL TRANSITS, LAKE ST. CLAIR, 1974 - 1980 (16)

YEAR	1974		1975		1976		1977		1978		1979		1980	
MONTH	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER
JANUARY	18	71	29	129	26	84	18	36	25	167	14	111	28	24
FEBRUARY	11	12	26	33	23	28	16	48	20	28	9	20	10	11
MARCH	19	78	22	59	34	57	44	68	9	49	22	43	8	17
APRIL	27	611	32	491	53	460	47	407	36	394	34	329	21	475
MAY	23	940	56	864	54	838	56	844	57	803	50	756	25	684
JUNE	27	912	68	866	46	829	56	868	49	808	49	797	35	615
JULY	21	959	49	829	53	860	48	848	74	903	42	825	33	582
AUGUST	39	868	43	775	38	832	43	640	61	863	33	822	33	524
SEPTEMBER	40	942	52	706	51	797	50	492	56	813	30	783	50	489
OCTOBER	38	934	67	766	58	785	34	440	47	810	43	811	50	486
NOVEMBER	39	919	31	614	46	733	45	405	40	738	45	700	47	490
DECEMBER	62	708	27	449	35	377	44	438	33	567	49	441	24	286
ANNUAL*	76	2,111	56	2,505	17	2,589	21	2,766	17	3,252	23	2,892	--	2,497
TOTAL	440	10,065	558	9,086	534	9,269	522	8,300	524	10,195	443	9,330	364	7,180
ANNUAL TOTALS	10,505		9,644		9,803		8,822		10,719		9,773		7,544	

Total Tanker Transits 1974 - 1979 = 3,021
Total Other Transits 1974 - 1979 = 56,245

TANKERS - tank ships and tank barges
OTHER - all other commercial vessels

*Annual - some fleets report only once per year.

TABLE VI-3 VESSEL TRANSITS, DETROIT RIVER, 1974 - 1980 (16)

YEAR	1974		1975		1976		1977		1978		1979		1980	
MONTH	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER	TANKERS	OTHER
JANUARY	56	169	90	281	84	261	50	149	81	358	35	368	82	141
FEBRUARY	61	119	77	144	66	214	60	153	94	243	31	98	56	131
MARCH	54	212	76	231	90	222	69	165	69	161	50	112	47	204
APRIL	65	816	96	634	125	605	88	551	113	560	73	550	65	709
MAY	76	1,154	108	1,048	128	1,000	98	1,001	126	1,026	111	878	80	844
JUNE	83	1,094	118	1,009	136	1,000	126	1,069	114	969	102	904	86	768
JULY	82	1,076	103	921	139	1,003	130	979	137	1,023	80	960	87	702
AUGUST	123	1,042	90	883	117	964	107	840	115	988	63	968	79	667
SEPTEMBER	98	1,092	97	809	118	945	90	625	105	923	98	934	90	623
OCTOBER	115	1,147	113	871	127	962	84	644	102	981	95	978	107	628
NOVEMBER	132	1,158	83	762	122	910	100	622	100	927	95	857	94	635
DECEMBER	162	915	74	612	103	569	94	715	86	698	90	582	59	339
ANNUAL*	28	3,489	--	6,176	--	6,144	--	6,429	--	6,689	--	6,162	--	5,047
TOTAL	1,135	13,483	1,125	14,381	1,355	14,799	1,096	13,942	1,242	15,546	923	14,351	932	11,438
ANNUAL TOTALS	14,618		15,506		16,154		15,038		16,788		15,274		12,370	

Total Tanker Transits 1974 - 1979 = 6,876
Total Other Transits 1974 - 1979 = 86,502

TANKERS - tank ships and tank barges
OTHER - all other commercial vessels

*Annual - some fleets report only once per year.

barges, while "other" vessels include passenger ships, dry cargo vessels (bulkers), dry cargo barges, towboats and tugboats. The categories of yachts, sail boats, and workboats are not included because these vessels do not have the potential to cause a large spill of petroleum products or other hazardous substances. The tankers and tank barges are shown separately because they present the most significant threat of a spill and these transit numbers are used later in the analysis. Note the high number of transits reported for each year. Local ferry traffic is also included in "other" transits in the St. Clair River, which makes the total number of transits unusually high. Also note that in addition to the transits reported by the month, there is a listing of annual transits because some fleet operators only report their activities once a year. This is unfortunate because the statistical computations in this study are made according to monthly vessel activity. Because the number of annual vessel transits is too large to ignore, they are divided up by month in Tables VI-8 to VI-13 in proportion to percentage of transits that have been reported to occur each month.

6.04 Table VI-2 shows vessel transits for Lake St. Clair. The same format is used as in Table VI-1. Note that the total number of annual transits for Lake St. Clair is much lower than for the St. Clair River. Table VI-3 shows the transit data for the Detroit River.

6.05 In order to evaluate the threat of ice to safe navigation, it is necessary to determine the proportion of vessel transits that have occurred in ice. This is done by multiplying the percent days per month with ice by the number of transits that occur in that month. Ice records for the St. Clair/Detroit River area were obtained from the "Summary of Great Lakes Weather and Ice Conditions" prepared by the National Oceanic and Atmospheric Administration (NOAA) (12). Tables VI-4 through VI-6 show ice records for the years covered by this study.

6.06 Safety of navigation on the waterway system is also a function of visibility conditions. The Detroit City Airport, which is adjacent to both Lake St. Clair and the Detroit River, is the only station in the area that has summarized records of visibility conditions for the years covered in this analysis. Selfridge Air National Guard Base records visibility conditions but these records have not been summarized and reducing this data is beyond the scope of this study. The former Grosse Isle Naval Air Station kept visibility records but they do not cover the period of time considered in this analysis. Table VI-7 shows the percent of the time that the visibility is low, which for this study is defined as less than one mile. These records are used to determine the number of transits that occurred in low visibility conditions.

TABLE VI-4 AVERAGE ICE CONDITIONS, ST. CLAIR RIVER
% DAYS WITH ICE, > 60% COVER (11,12)

MONTH	1974	1975	1976	1977	1978	1979	AVERAGE
JAN	0	0	39	68	39	23	28
FEB	17	0	0	50	100	25	32
MAR	0	0	0	0	68	0	11
APR	0	0	0	0	0	0	0
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DEC	0	0	23	0	0	0	4

TABLE VI-5 AVERAGE ICE CONDITIONS, LAKE ST. CLAIR
% DAYS WITH ICE, > 60% COVER (11,12)

MONTH	1974	1975	1976	1977	1978	1979	AVERAGE
JAN	84	23	68	100	100	100	79.2
FEB	100	64	50	100	100	100	85.7
MAR	0	0	0	50	100	68	38.5
APR	0	0	0	0	0	0	0
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DEC	0	0	39	68	0	0	18

TABLE VI-6 AVERAGE ICE CONDITIONS, DETROIT RIVER
% DAYS WITH ICE, > 60% COVER (11,12)

MONTH	1974	1975	1976	1977	1978	1979	AVERAGE
JAN	26	30	0	100	81	68	62
FEB	20	32	23	75	100	75	68
MAR	3	0	0	10	30	13	13
APR	0	0	0	0	16	0	4
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DEC	0	0	68	0	0	NO DATA	17

TABLE VI-7 LOW VISIBILITY CONDITIONS FOR THE ST. CLAIR/ DETROIT RIVER SYSTEM (17)

Observations Made at the Detroit City Airport, Adjacent to Lake St. Clair and the Detroit River

(Low Visibility - % Time Visibility is ≤ 1 Mile)

MONTH	YEAR 1974	1975	1976	1977	1978	1979	AVERAGE
JANUARY	7.3	0	3.6	4.9	16.5	5.2	6.3
FEBRUARY	5.4	10.7	2.6	2.7	0.4	2.7	4.1
MARCH	4.9	4.0	4.4	3.2	4.4	1.6	3.8
APRIL	0.4	2.5	0	1.3	3.3	3.3	1.8
MAY	2.0	1.6	0	2.4	1.2	0.4	1.3
JUNE	0	0.4	0.4	0.4	0	0	0.2
JULY	0.4	0	1.2	0.4	0	0.4	0.4
AUGUST	1.2	1.2	0.4	0.4	0	1.6	0.8
SEPTEMBER	0.8	2.6	2.5	2.1	0	1.3	1.6
OCTOBER	0.4	2.4	2.8	2.4	0.8	2.8	1.9
NOVEMBER	6.3	1.7	0	5.0	2.9	0.8	2.8
DECEMBER	8.1	6.0	3.2	6.9	5.2	6.0	5.9

6.07 Tables VI-8 through VI-13 show the monthly transits of tank ships and other vessels in good visibility conditions, low visibility conditions, and ice. These tables were developed from tables VI-1 to VI-3 by multiplying the number of transits by the percent occurrence of low visibility and ice conditions shown in Tables VI-4 to VI-7. The number of transits that occurred in good visibility, low visibility and ice are then used to compute the probability of an accident for each section of the Waterway System.

6.08 Figures VI-1 through VI-4 show seasonal traffic patterns for the St. Clair/Detroit River System. Figure VI-1 shows the average number of vessel transits for the St. Clair River from 1974 through 1980. First note that the scale for tanker transits appears on the left of the graph and the scale for "other" (bulker) transits appears on the right. The important thing to note is the trend of the traffic flow and the proportion of each type of vessel that moves each month. Figure VI-1 shows that the St. Clair River has no fixed season; traffic flows all year. Although tanker transits drop off in February and March, the difference between these low traffic months and the heaviest loads in the summer is not great. On the other hand, the bulker traffic tends to be more seasonal. Bulker traffic in January, February and March is off sharply from peak summer loads.

6.09 Figure VI-2 shows the average number of transits for Lake St. Clair. This section of the system is affected most by winter ice and consequently winter traffic tends to be much lower. Although winter tanker traffic drops off more sharply than in the St. Clair River, this reduction is not nearly as great as for the bulkers. Bulker traffic in Lake St. Clair in the winter is a very small percentage of traffic in the peak summer months.

6.10 Figure VI-3 shows that the Detroit River seasonal traffic pattern is much the same. Tanker traffic drops off in the winter but not as much as the bulker traffic. Figures VI-1 through VI-3 show that vessel traffic in the St. Clair/Detroit River System is indeed seasonal, but a substantial number of vessels operate in the system throughout the entire winter.

6.11 Figure VI-4 shows both U.S. and Canadian tanker transits in the St. Clair River for the years 1979 and 1980. (These are the only two years for which comparative data are presently available.) This figure shows that Canadian tankers are much more active in the St. Clair River than U.S. tankers. Except

TABLE VI-8 TANKER TRANSITS IN LOW VISIBILITY, GOOD VISIBILITY, AND ICE, ST. CLAIR RIVER 1974 - 1979
Low visibility is ≤ 1 mile. Number of low visibility transits and transits in ice are based on historical records shown in Tables VI-4 through VI-7.

YEAR	1974			1975			1976			1977			1978			1979		
MONTH	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE
JANUARY	33	3	0	83	0	0	61	2	25	47	2	33	52	10	24	45	3	11
FEBRUARY	44	2	8	60	7	0	61	2	0	41	1	21	54	0	54	49	1	13
MARCH	47	2	0	58	2	0	74	3	0	51	2	0	50	2	35	41	1	0
APRIL	63	0	0	65	2	0	85	0	0	73	1	0	64	2	0	71	2	0
MAY	48	1	0	94	2	0	78	0	0	75	2	0	74	1	0	87	0	0
JUNE	54	0	0	100	0	0	66	0	0	83	0	0	79	0	0	77	0	0
JULY	49	0	0	87	0	0	76	1	0	78	0	0	105	0	0	91	0	0
AUGUST	73	1	0	91	1	0	59	0	0	69	0	0	99	0	0	107	2	0
SEPTEMBER	93	1	0	77	2	0	68	2	0	73	2	0	83	0	0	85	1	0
OCTOBER	73	0	0	90	2	0	83	2	0	59	1	0	74	1	0	79	2	0
NOVEMBER	87	6	0	42	1	0	75	0	0	63	3	0	67	2	0	90	1	0
DECEMBER	85	8	0	50	3	0	62	2	15	65	5	0	67	4	0	101	6	0
TOTAL	749	24	8	897	22	0	848	14	40	777	19	54	868	22	113	923	19	24

Total Tanker Transits, St. Clair River, 1974 - 1979

Good Visibility - 5,062
Low Visibility - 120

TOTAL 5,182

Transits in Ice - 239

TABLE VI-9 OTHER TRANSITS IN LOW VISIBILITY, GOOD VISIBILITY, AND ICE, ST. CLAIR RIVER 1974 - 1979
Low visibility is $\leq$ 1 mile. Number of low visibility transits and transits in ice are based on historical records shown in Tables VI-4 through VI-7.

YEAR	1974			1975			1976			1977			1978			1979		
MONTH	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE
JAN.	2,909	229	0	3,970	0	0	1,530	57	619	648	33	463	1,680	332	785	1,564	86	380
FEB.	2,083	119	374	2,394	287	0	2,078	55	0	2,463	68	1,266	2,801	11	2,812	2,148	60	552
MAR.	3,244	167	0	2,932	122	0	4,315	199	0	4,495	149	0	3,533	163	2,513	4,543	74	0
APR.	5,301	21	0	4,363	112	0	6,079	0	0	4,916	65	0	4,886	167	0	5,293	181	0
MAY	6,022	123	0	5,824	95	0	6,387	0	0	6,301	155	0	5,867	71	0	9,500	38	0
JUNE	6,511	0	0	6,878	27	0	7,113	29	0	6,466	26	0	6,093	0	0	3,973	0	0
JULY	6,718	27	0	7,542	0	0	7,646	93	0	7,717	31	0	6,663	0	0	7,396	30	0
AUG.	6,763	82	0	6,463	79	0	7,312	29	0	7,592	30	0	6,430	0	0	7,202	117	0
SEPT.	6,386	52	0	5,863	157	0	6,414	164	0	5,000	107	0	6,857	0	0	6,752	89	0
OCT.	6,131	25	0	5,969	147	0	6,390	184	0	5,572	137	0	6,845	55	0	6,604	190	0
NOV.	5,132	305	0	6,539	113	0	5,992	0	0	5,077	267	0	3,347	100	0	5,785	47	0
DEC.	4,454	393	0	3,760	240	0	4,389	145	1,043	4,446	330	0	2,903	159	0	4,648	297	0
TOTAL	61,654	1,543	374	62,497	1,379	0	65,645	955	1,662	60,693	1,398	1,729	57,905	1,058	6,110	65,408	1,209	932

Total Other Transits, St. Clair River, 1974 - 1979

Good Visibility - 373,802
Low Visibility - 7,542

TOTAL 381,344

Transits in Ice - 10,807

TABLE VI-10 TANKER TRANSITS IN LOW VISIBILITY, GOOD VISIBILITY, AND ICE, LAKE ST. CLAIR, 1974 -1979
Low visibility is $\leq$ 1 mile. Number of low visibility transits and transits in ice are based on historical records shown in Tables VI-4 through VI-7.

YEAR	1974			1975			1976			1977			1978			1979		
MONTH	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE
JANUARY	20	2	18	33	0	8	26	1	18	18	1	19	22	4	26	14	1	15
FEBRUARY	12	1	13	25	3	18	23	1	12	17	0	17	21	0	21	9	0	9
MARCH	22	1	0	22	1	0	33	2	0	45	1	23	10	0	10	23	0	16
APRIL	33	0	0	33	1	0	55	0	0	48	1	0	36	1	0	35	1	0
MAY	27	1	0	62	1	0	56	0	0	57	1	0	58	1	0	53	0	0
JUNE	33	0	0	78	0	0	47	0	0	58	0	0	51	0	0	52	0	0
JULY	26	0	0	55	0	0	54	1	0	50	0	0	76	0	0	44	0	0
AUGUST	46	1	0	47	1	0	39	0	0	45	0	0	63	0	0	34	1	0
SEPTEMBER	48	0	0	56	2	0	52	1	0	51	1	0	58	0	0	31	0	0
OCTOBER	46	0	0	74	2	0	58	2	0	34	1	0	48	0	0	44	1	0
NOVEMBER	44	3	0	32	1	0	47	0	0	45	2	0	40	1	0	48	0	0
DECEMBER	68	6	0	27	2	0	35	1	14	43	3	31	32	2	0	49	3	0
TOTAL	425	15	31	544	14	26	525	9	44	511	11	90	515	9	57	436	7	40

Total Tanker Transits, St. Clair River, 1974 - 1979

Good Visibility - 2,956
Low Visibility - 65

TOTAL 3,021

Transits in Ice - 288

TABLE VI-11 OTHER TRANSITS IN LOW VISIBILITY, GOOD VISIBILITY, AND ICE, LAKE ST CLAIR, 1974 - 1979
Low visibility is ≤ 1 mile. Number of low visibility transits and transits in ice are based on historical records shown in Tables VI-4 through VI-7.

YEAR	1974			1975			1976			1977			1978			1979		
MONTH	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE
JANUARY	85	7	77	177	0	41	104	4	73	60	3	63	191	38	229	157	9	166
FEBRUARY	11	1	12	49	6	35	27	1	14	74	2	76	28	0	28	19	1	20
MARCH	94	5	0	79	3	0	77	4	0	93	3	48	76	3	79	68	1	47
APRIL	777	3	0	647	17	0	641	0	0	593	8	0	566	19	0	455	16	0
MAY	1,166	24	0	1,169	19	0	1,175	0	0	1,229	30	0	1,177	14	0	1,097	4	0
JUNE	1,142	0	0	1,185	5	0	1,135	5	0	1,305	5	0	1,196	0	0	1,143	0	0
JULY	1,205	5	0	1,152	0	0	1,183	14	0	1,258	5	0	1,321	0	0	1,194	5	0
AUGUST	1,085	13	0	1,061	13	0	1,138	5	0	968	4	0	1,249	0	0	1,176	19	0
SEPTEMBER	1,182	10	0	955	25	0	1,080	28	0	725	16	0	1,201	0	0	1,111	15	0
OCTOBER	1,177	5	0	1,039	26	0	1,065	31	0	645	15	0	1,188	10	0	1,150	33	0
NOVEMBER	1,095	74	0	823	14	0	1,018	0	0	569	30	0	1,062	32	0	1,008	8	0
DECEMBER	826	73	0	585	37	0	517	17	208	614	45	448	781	43	0	603	38	0
TOTAL	9,845	220	89	8,921	165	76	9,160	109	295	8,133	167	635	10,036	159	336	9,181	149	233

Total Other Transits, St. Clair River, 1974 - 1979

Good Visibility - 55,276
Low Visibility - 969

TOTAL 56,245

Transits in Ice - 1,664

TABLE VI-12 TANKER TRANSITS IN LOW VISIBILITY, GOOD VISIBILITY, AND ICE, DETROIT RIVER, 1974 - 1979
Low visibility is $\leq$ 1 mile. Number of low visibility transits and transits in ice are based on historical records shown in Tables VI-4 through VI-7.

YEAR	1974			1975			1976			1977			1978			1979		
MONTH	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE
JANUARY	53	4	15	90	0	27	81	3	0	48	2	50	68	13	66	33	2	23
FEBRUARY	60	3	13	69	8	25	64	2	15	58	2	45	94	0	94	30	1	23
MARCH	52	3	2	73	3	0	86	4	0	67	2	7	66	3	21	49	1	7
APRIL	67	0	0	94	2	0	125	0	0	87	1	0	109	4	18	71	2	0
MAY	76	2	0	106	2	0	128	0	0	96	2	0	124	2	0	111	0	0
JUNE	85	0	0	118	0	0	135	1	0	125	1	0	114	0	0	102	0	0
JULY	84	0	0	103	0	0	137	2	0	129	1	0	137	0	0	80	0	0
AUGUST	124	2	0	89	1	0	117	0	0	107	0	0	115	0	0	62	1	0
SEPTEMBER	100	1	0	94	3	0	115	3	0	88	2	0	105	0	0	97	1	0
OCTOBER	118	0	0	110	3	0	123	4	0	82	2	0	101	1	0	92	3	0
NOVEMBER	126	9	0	82	1	0	122	0	0	95	5	0	97	3	0	94	1	0
DECEMBER	153	13	0	70	4	0	100	3	70	88	6	0	82	4	0	85	5	0
TOTAL	1,098	37	30	1,098	27	52	1,333	22	85	1,070	26	102	1,212	30	199	906	17	53

Total Tanker Transits, Detroit River, 1974 - 1979

Good Visibility - 6,717
Low Visibility - 159

TOTAL 6,876

Transits in Ice - 521

TABLE VI-13 OTHER TRANSITS IN LOW VISIBILITY, GOOD VISIBILITY, AND ICE, DETROIT RIVER 1974 - 1979
Low visibility is $\leq$ 1 mile. Number of low visibility transits and transits in ice are based on historical records shown in Tables VI-4 through VI-7.

YEAR	1974			1975			1976			1977			1978			1979		
MONTH	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	ICE
JAN.	211	17	59	490	0	147	428	16	0	262	14	276	524	104	509	611	34	439
FEB.	152	9	32	228	27	82	357	10	84	277	7	213	424	2	426	167	5	129
MAR.	271	14	7	387	16	0	364	17	0	296	10	31	271	12	85	193	3	25
APR.	1,098	4	0	1,082	28	0	1,034	0	0	1,009	13	0	951	32	157	932	32	0
MAY	1,524	31	0	1,810	29	0	1,712	0	0	1,813	45	0	1,779	22	0	1,533	6	0
JUNE	1,475	0	0	1,759	7	0	1,705	7	0	1,978	8	0	1,701	0	0	1,584	0	0
JULY	1,447	6	0	1,612	0	0	1,694	21	0	1,810	7	0	1,796	0	0	1,675	7	0
AUG.	1,388	17	0	1,530	19	0	1,638	7	0	1,551	6	0	1,734	0	0	1,669	27	0
SEPT.	1,460	12	0	1,383	37	0	1,575	40	0	1,136	24	0	1,620	0	0	1,616	21	0
OCT.	1,542	6	0	1,489	37	0	1,598	46	0	1,166	29	0	1,708	14	0	1,666	48	0
NOV.	1,465	98	0	1,313	23	0	1,555	0	0	1,096	58	0	1,580	47	0	1,490	12	0
DEC.	1,136	100	0	1,010	65	0	944	31	663	1,235	92	0	1,161	64	0	959	61	0
TOTAL	13,169	314	98	14,093	288	229	14,604	195	747	13,629	313	520	15,249	297	1,177	14,095	256	593

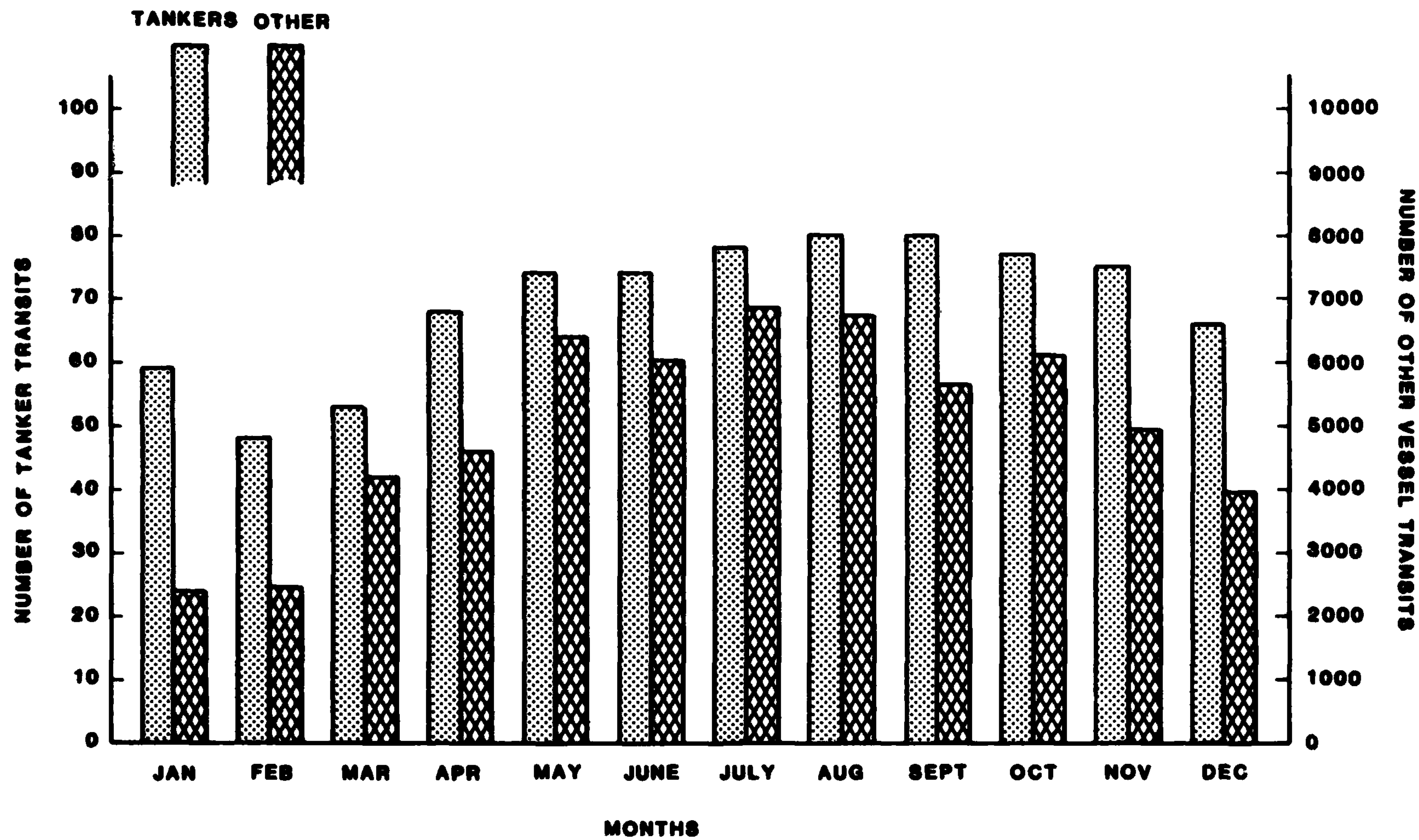
Total Other Transits, Detroit River, 1974 - 1979

Good Visibility - 84,839
Low Visibility - 1,663

TOTAL 86,502

Transits in Ice - 3,364

FIGURE VI-I AVERAGE NUMBER OF VESSEL TRANSITS, ST.CLAIR RIVER, 1974-1980



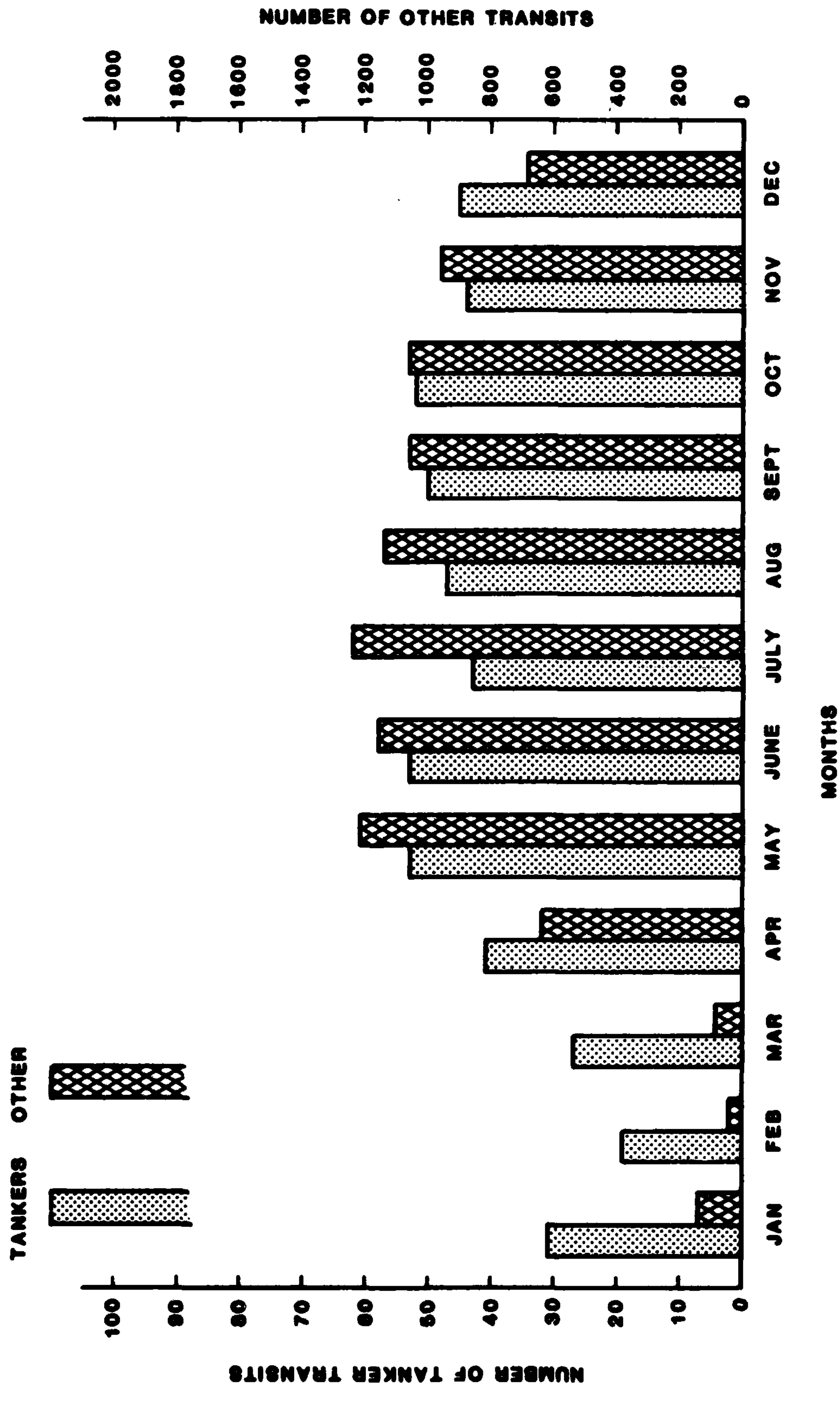


FIGURE VI-2 AVERAGE NUMBER OF TRANSITS, LAKE ST. CLAIR, 1974-1979

FIGURE VI-3 AVERAGE NUMBER OF TRANSITS, DETROIT RIVER, 1974-1979

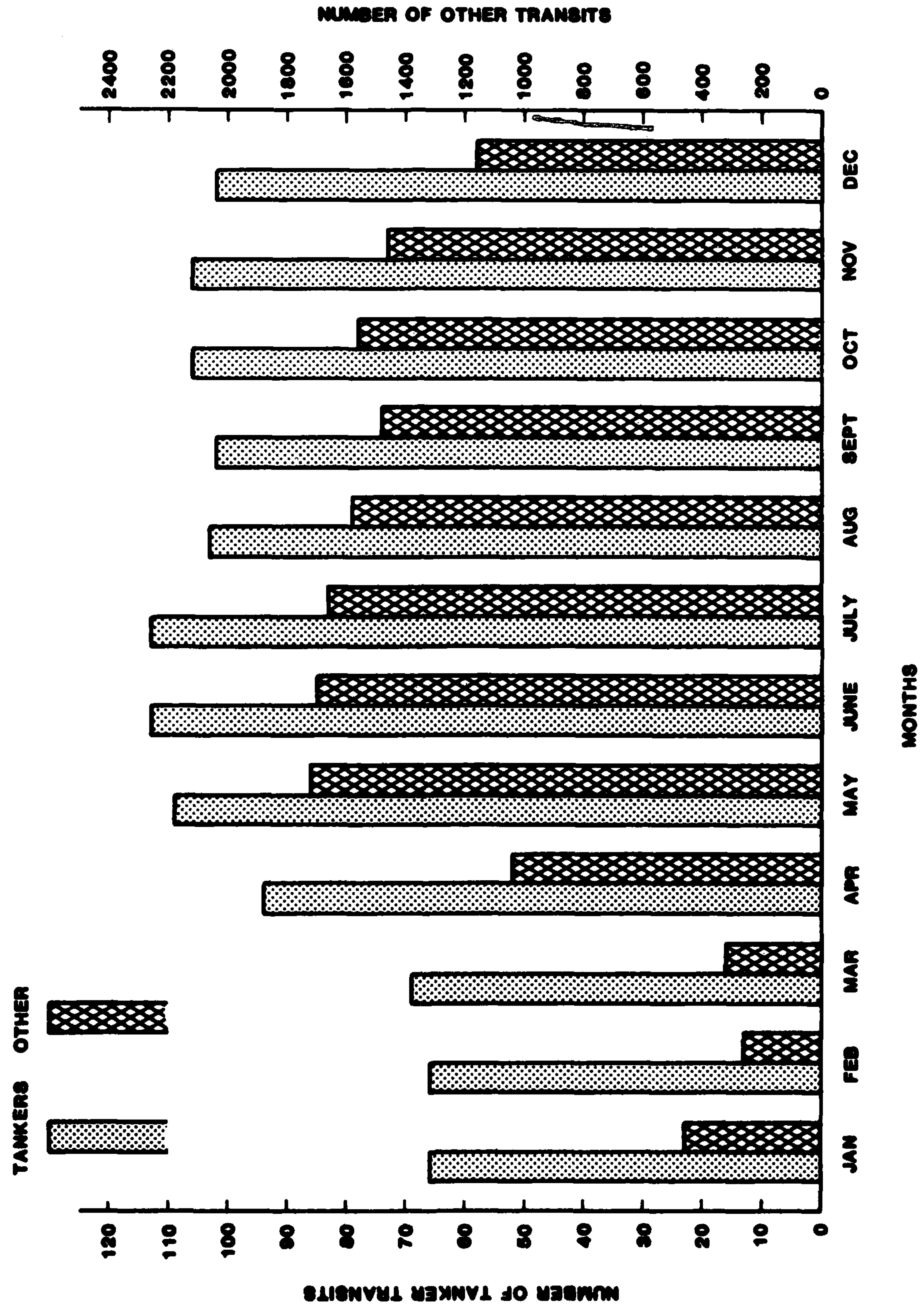
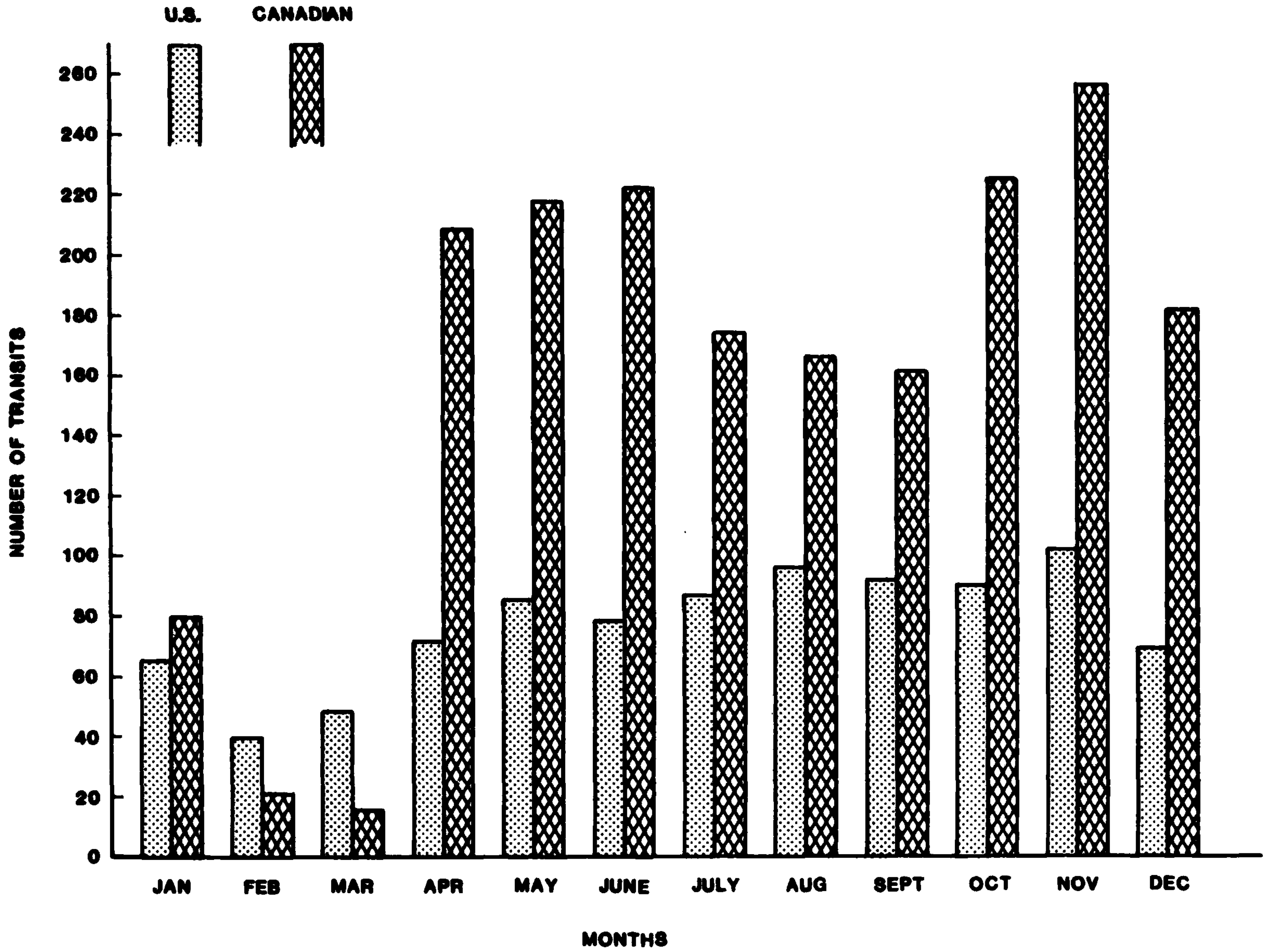


FIGURE VI-4 AVERAGE MONTHLY TANKER TRANSITS, ST. CLAIR RIVER, 1979-1980
U.S. AND CANADIAN TANKERS (16, 18)



in the winter months, U.S. tankers are only about a third of the total traffic. Also note that the Canadian tanker traffic is much more seasonal than the U.S. traffic. The U.S. activity remains fairly level over the entire season while the Canadian tanker fleet nearly stops operations in the winter. The transit records show that the Canadian fleet starts building up fuel supplies in early summer then begins an even more active stockpiling effort in early fall. Canadian experience cannot be used for the accident and spill analysis because transit records were not maintained earlier than 1979 and accident and spill records are not available .

6.12 In summary, transit records show that the St. Clair/Detroit River System is open to navigation all year, although traffic may be temporarily halted by ice jams in the St. Clair River and the Detroit River or heavy ice conditions in Lake St. Clair. Fleet operators report that if full season icebreaker support were furnished, the traffic levels would be increased. For tankers, winter icebreaker assistance would probably mean that additional petroleum products would be shipped by water. Water shipping rates are roughly a third of rail rates, therefore in a light ice year, or when full icebreaker assistance is provided, it should be much cheaper to move these products in tankers. This means that increased icebreaker support is likely to result in higher levels of tanker traffic. On the other hand, bulkers are generally engaged in shipping commodities such as ore and coal. The demand for these commodities depends on economic conditions and additional quantities are not likely to be shipped if the waterways are open in the winter. Ore and coal shipments are, however, likely to be distributed more evenly over the entire year. The benefit would be that less stockpiling would be required by steel mills. Winter bulker traffic would still be lower than in summer, but the percentage of decrease would not be as great.

6.13 Because of the special characteristics of the St. Clair/-Detroit River System, estimating transits for Great Lakes Waterway extended season periods becomes an exercise in determining the extent to which tanker traffic would be increased because of icebreaker support and determining the extent to which bulker traffic would be equalized over the entire season. Tanker fleet operators have indicated that with full icebreaker support winter transits might increase by about 20%. This would probably represent a net total increase in petroleum products shipped by water. Bulk carriers in the ore trade, which accounts for most of the bulker transits, have wider differences in demand for their product because of economic conditions. In good economic conditions, more ore would be shipped in the winter if icebreaker support was available. Shipments would probably not be evenly distributed over the entire year, however, because of traditional stockpiling customs and because it could still be more difficult and expensive to operate ships in the winter. Following this reasoning, it was concluded that winter shipments of petroleum products would be increased by about 20% if icebreaker support was provided, and that bulker shipments would be equalized over the entire year by the same amount. Vessel transits for the traditional extended season periods were estimated by increasing average winter seasonal transits by 20%. Transits were increased in proportion to the number of days in each of the proposed extended season periods. Tables VI-14 through VI-16 shows the results of these computations. Increases in each case were made based on historic monthly transit records.

Vessel Accidents and Spills

Vessel Accidents

6.14 Data on vessel accidents used in this analysis are taken from U.S. Coast Guard casualty records. These casualty records tabulate many kinds of incidents (19). Some of these incidents are occurrences that can clearly be recognized as vessel "accidents", while others are material failures or equipment failures. Casualty data that are related to vessel accidents include the following:

- Grounding
- Collision
- Foundering
- Capsizing
- Flooding
- Heavy Weather Damage.

6.15 A large number of casualty reports concern material failures that are related to vessel's structure, machinery, and associated engineering equipment. Most of these material failures are not "accidents" in the sense that they could be related to an oil spill or to the threat of a spill. Because of

TABLE VI-14 ESTIMATED TANKER TRANSITS DURING EXTENDED SEASON OPERATIONS, ST. CLAIR RIVER

SEASON	NUMBER OF DAYS	NUMBER OF ADDITIONAL DAYS	ADDITIONAL TRANSITS	TRANSITS IN		
				GOOD VISIBILITY	LOW VISIBILITY	ICE
1 APRIL - 15 DEC. (BASELINE)	259	0	0			
16 DEC. - 15 JAN.	290	31	14	13	1	3
16 DEC. - 14 FEB.	320	61	24	22	2	6
25 MARCH - 1 APRIL	266	7	3	3	0	0
18 MARCH - 1 APRIL	273	14	5	5	0	1
YEAR-ROUND	365	106	41	39	2	8

TABLE VI-15 ESTIMATED TANKER TRANSITS DURING EXTENDED SEASON OPERATIONS, LAKE ST. CLAIR

SEASON	NUMBER OF DAYS	NUMBER OF ADDITIONAL DAYS	ADDITIONAL TRANSITS	TRANSITS IN		
				GOOD VISIBILITY	LOW VISIBILITY	ICE
1 APRIL - 15 DEC. (BASELINE)	259	0				
16 DEC. - 15 JAN.	290	31	7	6	1	3
16 DEC. - 14 FEB.	320	61	12	10	2	6
25 MARCH - 1 APRIL	266	7	1	1	0	0
18 MARCH - 1 APRIL	273	14	2	2	0	1
YEAR-ROUND	365	106	19	17	2	9

TABLE VI-16 ESTIMATED TANKER TRANSITS DURING EXTENDED SEASON OPERATIONS, DETROIT RIVER

SEASON	NUMBER OF DAYS	NUMBER OF ADDITIONAL DAYS	ADDITIONAL TRANSITS	TRANSITS IN		
				GOOD VISIBILITY	LOW VISIBILITY	ICE
1 APRIL - 15 DEC. (BASELINE)	259	0				
16 DEC. - 15 JAN.	290	31	17	15	2	4
16 DEC. - 14 FEB.	320	61	30	27	3	11
25 MARCH - 1 APRIL	266	7	3	3	0	0
18 MARCH - 1 APRIL	273	14	6	6	0	1
YEAR-ROUND	365	106	50	46	4	15

this, material failures are not included in the accident data used in this analysis.

6.16 To perform an analysis of the probability of a vessel accident and the probability of a spill, it is necessary to establish categories of accidents that are clearly related to spills, and accidents that are related to the basic statistic of the St. Clair/Detroit River Waterway, which is vessel transits. Groundings and collisions are accident categories that are related to spills, and also can be related to vessel transits. Further, these accidents can be related to the chief environmental cause of accidents; low visibility. Records show that more collisions and groundings occur in low visibility conditions, therefore these categories are expanded to include accidents that occur in good visibility and accidents that occur in low visibility. Since winter transits are of particular concern in this study, collisions with ice are included as a separate accident category. Although a category of groundings in ice was not included in an earlier study describing the St. Marys River, groundings in ice have occured in the St. Clair/ Detroit River System as a result of ships being forced out of the channel by moving ice, or ships beset by ice drifting out of the channel. The category of grounding in ice has therefore been added to this analysis.

6.17 Tables VI-17 through VI-19 summarize the records of ship accidents in the St. Clair/Detroit River System for the period 1974 through 1979. All designated categories of accidents are included on these tables even though in some cases no accidents occurred. For example, there were no collisions with ice in low visibility anywhere in the system during the period of this report. In the sections that follow, these accident records are used to compute the probability of an accident on a single ship transit using the total number of transits recorded for the same period of time.

6.18 Table VI-20 provides an accident summary for the entire area. This table can be used to make some observations concerning the hazards to navigation in each section of the System. First note the accident records for the St. Clair River. Although the St. Clair River has many more transits than any of the other sections of the system, the accident rate is very low. To illustrate this observation, note that the St. Clair River has four times the number of transits as the Detroit River but only 13% of the accidents. This condition can probably be explained by the fact that the St. Clair River does

TABLE VI-17 SHIP ACCIDENTS IN ST. CLAIR RIVER, 1974-1979

YEAR	GROUNDING						COLLISION				COLLISION WITH ICE				ANNUAL TOTAL
	GOOD VISIBILITY		LOW VISIBILITY		ICE		GOOD VISIBILITY		LOW VISIBILITY		GOOD VISIBILITY		LOW VISIBILITY		
	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	
1974		1			1										2
1975		1						1							2
1976							1								1
1977		1													1
1978		2		1						1		1			5
1979		1													1
TOTAL		6		1	1		1	1		1		1			12

TANKER - Includes tank ships and tank barges

OTHER - Includes freighters, bulkers, tugs, and government vessels

GROUNDING, ICE - Includes groundings of ships forced out of the channel by ice or ships grounded while beset in moving ice fields

COLLISION WITH ICE - Includes both collisions with ice and collisions caused by ice, such as leading ship stopped by ice then hit by following ship, or ship deflected off ice then collides with adjacent ship.

TABLE VI-18 SHIP ACCIDENTS IN LAKE ST. CLAIR, 1974-1979

YEAR	GROUNDING						COLLISION				COLLISION WITH ICE				ANNUAL TOTAL
	GOOD VISIBILITY		LOW VISIBILITY		ICE		GOOD VISIBILITY		LOW VISIBILITY		GOOD VISIBILITY		LOW VISIBILITY		
	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	
1974		1						1							2
1975		2		1			1								4
1976				1		2									3
1977		1		1							1				3
1978		2				2									4
1979															0
TOTAL		6		3		4	1	1			1				16

TANKER - Includes tank ships and tank barges

OTHER - Includes freighters, bulkers, tugs, and government vessels

GROUNDING, ICE - Includes groundings of ships forced out of the channel by ice or ships grounded while beset in moving ice fields

COLLISION WITH ICE - Includes both collisions with ice and collisions caused by ice, such as leading ship stopped by ice then hit by following ship, or ship deflected off ice then collides with adjacent ship.

TABLE VI-19 SHIP ACCIDENTS IN THE DETROIT RIVER

YEAR	GROUNDING						COLLISION				COLLISION WITH ICE				ANNUAL TOTAL
	GOOD VISIBILITY		LOW VISIBILITY		ICE		GOOD VISIBILITY		LOW VISIBILITY		GOOD VISIBILITY		LOW VISIBILITY		
	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	TANKER	OTHER	
1974		5				2	2	10		1		1			21
1975							4	9							13
1976		3					1	8				1			13
1977		2				1	1	6				6			16
1978		3				1		11				3			18
1979		1						8							9
TOTAL		14				4	8	52		1		11			90

TANKER - Includes tank ships and tank barges

OTHER - Includes freighters, bulkers, tugs, and government vessels

GROUNDING, ICE - Includes groundings of ships forced out of the channel by ice or ships grounded while beset in moving ice fields

COLLISION WITH ICE - Includes both collisions with ice and collisions caused by ice, such as leading ship stopped by ice then hit by following ship, or ship deflected off ice then collides with adjacent ship.

TABLE VI-20 SUMMARY OF ACCIDENT RECORDS, ST. CLAIR/ DETROIT RIVER SYSTEM, 1974 -1979

	GROUNDING	COLLISION	COLLISION WITH ICE	TOTAL ACCIDENTS
St. Clair River	8	3	1	12
Lake St. Clair	13	2	1	16
Detroit River	18	61	11	90
Total	39	66	13	118
Percent of Total	33	56	11	100

not have much activity in ports and restricted channels. The St. Clair River is generally quite deep with navigable water bank-to-bank except for the shoal areas opposite Marine City and St. Clair, Michigan. Having through traffic in a relatively open channel results in a low accident rate. It is also interesting to note that there are not many accidents in ice, only one in a six year period, even though ice sometimes jams at the Blue Water Bridge and in the St. Clair delta.

6.19 Lake St. Clair has a relatively low number of accidents for a shoal area with a restricted channel. There are not even many accidents in ice (five in six years) even though the Lake is completely frozen over for two months of the year. By far most of the accidents in Lake St. Clair are groundings. Although groundings present some danger of large spills, none have occurred in Lake St. Clair because nearly all of the bottom adjacent to the channel is soft mud; therefore, a grounding is not dangerous in this area.

6.20 The Detroit River has a relatively large number of vessel accidents. This is because much of the Detroit River is in an intensely developed industrial area with busy ports. A large percentage of the accidents occur in narrow channels in these industrial areas, such as the Rouge River and the Trenton Channel. Most of the collisions are minor accidents that result from large vessels maneuvering in highly restricted waters. Collisions with piers, bridges, and loading vessels in turning basins are common. Since most of the Detroit River is very deep, the incidence of grounding accidents is much lower than in other sections of the system. Although a grounding of a tanker in the rocky southern section of the Detroit River would present the threat of a large spill, none has occurred during the time covered by these records.

6.21 Tables VI-21 through VI-23 show where the accidents have occurred. For the St. Clair River, most of the groundings have occurred on the shoal opposite St. Clair, Michigan. A collision with ice occurred at the Blue Water Bridge where ice often jams before it becomes attached to the shoreline. Collisions with ships have been in the southern section of the channel. On Lake St. Clair, grounding is the principal hazard to navigation, and of the groundings, most occur adjacent to Grosse Point. This situation may indicate that the over-the-shoulder range used by ships outbound from the Detroit River may be inadequate.

TABLE VI-21 ACCIDENT LOCATIONS, ST. CLAIR RIVER, 1974-1979

GROUNDINGS	
Blue Water Bridge	1
Port Huron	1
Russell Island	1
St. Clair, Michigan	3
St. Clair Cutoff Channel	1
Salt Dock (S. of Marine City)	1
	8
COLLISONS	
Ice	
Blue Water Bridge	1
Ships	
Recors Lower Light (N. of Marine City)	1
St. Clair Cutoff Channel	1
	2

TABLE VI-22 ACCIDENT LOCATIONS, LAKE ST. CLAIR, 1974-1979

GROUNDINGS	
Abeam Grosse Point	5
St. Clair Light	2
Cutoff Channel	3
	10
COLLISONS	
Submerged Objects	
Cutoff Channel	1
Ships	
Abeam Grosse Point	2
St. Clair Light	1
	3

TABLE VI-23 ACCIDENT LOCATIONS, DETROIT RIVER, 1974-1979

GROUNDINGS

Amherstburg Channel	1
Ballard Reef Channel	1
Bar Point Junction	1
Belle Isle	1
Detroit River Light	2
Fighting Island	2
Trenton Channel	6
Wyandotte Channel	3
Unknown	1
	18

COLLISONS

Ice

Detroit River Light	3
East Outer Channel	4
	7

Navigation Aids

Belle Isle, North Channel	2
Wyandotte	1
	3

Submerged Objects

Ballards Reef Channel	1
Rouge River	3
Trenton Channel	1
	5

Ships

Belle Isle	1
Detroit Harbor Dock	2
Detroit River Light	2
East Outer Channel	2
Ecorse	5
Fighting Island	2
Livingstone Channel	2
Rouge River	6
Trenton Channel	6
Wyandotte	1
Zug Island	3
	32

Piers

Amherstburg	1
Detroit Harbor Terminal	1
Ecorse	4
Rouge River	6
Trenton Channel	1
Windsor	1
Wyandotte	2
Zug Island	2
	18

Other Structures

Grosse Ile (Bridge)	2
Rouge River	5
- Amtrack Bridge	
- Delray Bridge	
- Conrail Bridge (2)	
- Fort Street Bridge	
	7

6.22 Most of the accidents in the Detroit River are associated with terminals and piers. Although some potentially dangerous groundings occurred in the rocky areas of the Amherstburg Channel and Ballard Reef Channel, most occurred in the highly restricted waters of the Trenton Channel and Wyandotte Channel. Collisions occurred in many locations, but most happen in the terminal areas: Wyandotte, Trenton, and especially the Rouge River. It appears that nearly every bridge spanning the Rouge River has suffered at least one collision. This, of course, can be explained by the fact that the Rouge River has a very narrow channel and has a great many large lakers calling at the Ford Motor Company at the end of the channel. Thus even though the Detroit River has a large number of accidents, most are minor collisions in port areas that present a low risk of a major spill of petroleum products or hazardous substances.

6.23 Since a large portion of the tanker traffic in the St. Clair River belongs to Canadian fleets, the reader may be concerned about the accident rates and spill potential of these vessels. Complete accident and spill information was not available from the Canadian government. However, in an interview with an official at the Canadian Coast Guard Headquarters at Ottawa, it was determined that only three Canadian vessel accidents could be identified in the St. Clair/Detroit River area. Each of these accidents was a grounding but none resulted in a spill (20).

Vessel Spills

6.24 Although a great many spills have occurred in the St. Clair/Detroit River area resulting from vessel operations, only a few were the result of a vessel accident. Table VI-24 shows all of the spills that resulted from accidents during the six year period covered by this study. All of the spills occurred in the Detroit River and all ocurred as the result of collisions. Further, all of the spills were very small, only 8 gallons per spill on the average, and records show that 84% of the spilled product was recovered. Based on these records, one could assume that the threat of a major spill event in the St. Clair/Detroit River System is minimal. There have, however, been many spills that were not caused by vessel accidents. These events will be reviewed in the paragraphs and tables that follow.

TABLE VI-24 SPILLS RESULTING FROM SHIP ACCIDENTS, ST. CLAIR/DETROIT RIVER SYSTEM, 1974 - 1979 (21)

YEAR	SHIP TYPE	LOCATION	ACCIDENT	PRODUCT	AMOUNT (GAL)	RECOVERED (GAL)
1975	Tank Barge	Detroit River	Collision	#6 Fuel Oil	10	8
1975	Tank Barge	Detroit River	Collision With Pier	#6 Fuel Oil	10	10
1979	Tug	Rouge River	Collision With Ice	Dist. Fuel	5	3
Totals			3		25	21

Average Spill Size - 8 gallons

Percent Recovered - 84

6.25 Vessel spills that do not result from accidents have been divided into four categories:

- Operational spills
- Loading/unloading spills
- Mystery spills, and
- Intentional discharges.

Table VI-25 shows the operational spills that occurred in the St. Clair River and Lake St. Clair. Operational spills are typically valve malfunctions, fuel line failures, and personnel errors. Although none of the operational spills is large, they are all as large or larger than the spills caused by accidents. The single loading spill reported on Table VI-26 is also relatively small. Some of the mystery spills shown on Table VI-27 are somewhat larger. A mystery spill is an intentional discharge in which the offender was not caught, or some other type of spill that went unreported. Unfortunately, a rather large number of spills have gone unreported.

6.26 Table VI-28 shows that in the Detroit River non-accident spills are even a greater problem. Operational spills have been relatively large and numerous. Loading/unloading spills have also been frequent, but the individual spills were not as large. Table VI-30 shows that in the industrial Detroit River the unreported mystery spills are a major problem. Comparing the amount of petroleum spilled with Table VI-24, the unreported spills involve nearly 2700 times the amount of oil that is spilled by vessel accidents. However, in recent years the number and size of the unreported spills seems to be decreasing. On the other hand, the lower levels of unreported spills may also be a result of cuts in funds for surveillance operations so that in recent years the unreported spills are simply not found. These records make a strong arguement for greater efforts in surveillance and enforcement.

6.27 The final Table VI-3 records intentional discharges in the Detroit River. These are cases in which operators have deliberately broken the law. It appears that this situation was corrected in the years 1980 and 1981. This may be true, or it may also indicate that because of reduced surveillance efforts the intentional discharges have not been detected.

TABLE VI-25 OPERATIONAL SPILLS, ST. CLAIR RIVER AND LAKE ST. CLAIR, 1974-1981 (21)

(Non-accident spills that occurred while vessels were underway or from ship related activities.)

A. NUMBER OF SPILLS PER YEAR

YEAR	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
1974	3	10	3
1975	0		
1976	0		
1977	0		
1978	0		
1979	1	60	60
1980	2	35	18
1981	1		
TOTAL	7	105	

B. NUMBER OF SPILLS ACCORDING TO SUBSTANCE

SUBSTANCE	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
Gasoline	1	60	60
Light diesel oil	1	10	10
Heavy diesel oil	1	10	10
Unidentified light oil	2	0	0
Other oil	2	25	13
TOTAL	7	105	

- Average number of spills per year - 1
- Average amount per spill (gal) - 15
- Average amount spilled per year (gal) - 13

TABLE VI-26 LOADING/UNLOADING SPILLS, ST. CLAIR RIVER AND LAKE ST. CLAIR, 1974-1981 (21)

(Spills during transfer of hazardous substances)

A. NUMBER OF SPILLS PER YEAR

YEAR	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
1974	0		
1975	1	250	250
1976	0		
1977	0		
1978	0		
1979	0		
1980	0		
1981	0		
TOTAL	1	250	

B. NUMBER OF SPILLS ACCORDING TO SUBSTANCE

SUBSTANCE	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
Gasoline	1	250	250

- There were no intentional discharges in the St. Clair River and Lake St. Clair.

TABLE VI-27 MYSTERY SPILLS, ST. CLAIR RIVER AND LAKE ST. CLAIR, 1974-1981 (21)

(Spills of Unknown Source)

A. NUMBER OF SPILLS PER YEAR

YEAR	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
1974	0		
1975	2	15	8
1976	3	12	4
1977	8	47	6
1978	9	338	38
1979	10	309	31
1980	5	61	12
1981	1	1	1
TOTAL	38	783	

B. NUMBER OF SPILLS ACCORDING TO SUBSTANCE

SUBSTANCE	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
Gasoline	3	12	4
Other distillate fuel oil	5	75	15
Light diesel oil	1	20	20
Waste oil	5	106	22
Lube oil	1	250	250
Hydraulic fluid	1	3	3
Unidentified light oil	17	160	9
Unidentified heavy oil	2	155	78
Other oil	2	1	1
Other hazardous substance	1	1	1
TOTAL	38	783	

- Average number of spills per year - 5
- Average amount per spill (gal) - 21
- Average amount spilled per year (gal) - 98

TABLE VI-28 OPERATIONAL SPILLS, DETROIT RIVER, 1974-1981 (21)

(Non-accident spills that occurred at sea or from ship related activities.)

A. NUMBER OF SPILLS PER YEAR

YEAR	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
1974	9	1,908	212
1975	3	110	37
1976	4	21	5
1977	1	84	84
1978	7	115	16
1979	6	30	5
1980	2	11	6
1981	2	9	5
TOTAL	34	2,288	

B. NUMBER OF SPILLS ACCORDING TO SUBSTANCE

SUBSTANCE	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
Crude oil	1	0	0
Heavy crude	1	4	4
Gasoline	1	2	2
Fuel oil	2	101	51
Light diesel oil	6	123	21
Heavy diesel oil	1	10	10
#6 fuel oil	4	1,590	398
Waste oil	6	421	70
Lube oil	1	3	3
Petrol. prod. mixture	1	2	2
Unidentified light oil	8	26	3
Other oil	1	1	1
Lacquer based paint	1	5	5
TOTAL	34	2,288	

- Average number of spills per year - 4
- Average amount per spill (gal) - 67
- Average amount spilled per year (gal) - 286

TABLE VI-29 LOADING/UNLOADING SPILLS, DETROIT RIVER, 1974-1981 (21)

(Spills during transfer of hazardous substances.)

A. NUMBER OF SPILLS PER YEAR

YEAR	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
1974	1	1	1
1975	1	1	1
1976	3	82	27
1977	5	87	17
1978	3	61	20
1979	3	7	2
1980	2	20	10
1981	3	3	1
TOTAL	21	262	

B. NUMBER OF SPILLS ACCORDING TO SUBSTANCE

SUBSTANCE	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
Heavy crude	1	2	2
Other fuel oil	3	110	37
Light diesel oil	1	10	10
Heavy diesel oil	2	9	5
# 6 fuel oil	10	115	12
Coal tar	1	10	10
Animal oil	1	1	1
Unidentified light oil	2	5	3
TOTAL	21	262	

- Average number of spills per year - 3
- Average amount per spill (gal) - 12
- Average amount spilled per year (gal) - 33

TABLE VI-30 MYSTERY SPILLS, DETROIT RIVER, 1974-1981 (21)

(Spills of Unknown Source)

A. NUMBER OF SPILLS PER YEAR

YEAR	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
1974	8	3,252	407
1975	16	19,738	1234
1976	43	38,557	897
1977	40	2,029	51
1978	51	1,110	22
1979	44	1,161	26
1980	32	564	18
1981	13	189	15
TOTAL	247	66,600	

B. NUMBER OF SPILLS ACCORDING TO SUBSTANCE

SUBSTANCE	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
Crude oil	1	20	20
Heavy crude	2	250	125
Gasoline	1	10	10
Other fuel oil	1	150	150
Light diesel oil	1	1	1
#6 fuel oil	4	6,633	1658
Waste oil	46	22,140	481
Lube oil	2	103	52
Grease	3	25	8
Petrol. prod. mixture	1	0	0
Unidentified light oil	156	1,380	9
Unidentified heavy oil	19	35,823	1886
Other oil	3	4	1
Other hazardous substance	1	10	10
Animal oil	3	40	13
Lacquer based paint	2	1	1
Paraffin wax	1	10	10
TOTAL	247	66,600	

- Average number of spills per year - 31
- Average amount per spill (gal) - 270
- Average amount spilled per year (gal) - 8,325

TABLE VI-31 INTENTIONAL DISCHARGES, DETROIT RIVER, 1974-1981 (21)

A. NUMBER OF SPILLS PER YEAR

YEAR	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
1974	0		
1975	0		
1976	1	200	200
1977	2	57	29
1978	2	170	85
1979	3	15	8
1980	0		
1981	0		
TOTAL	8	442	

B. NUMBER OF SPILLS ACCORDING TO SUBSTANCE

SUBSTANCE	NUMBER OF SPILLS	AMOUNT (gal)	AVERAGE AMOUNT PER SPILL (gal)
Heavy diesel oil	1	50	50
Waste oil	2	25	13
Unidentified light oil	2	12	6
Unidentified heavy oil	3	355	118
TOTAL	8	422	

- Average number of spills per year - 1
- Average amount per spill (gal) - 55
- Average amount spilled per year (gal) - 55

6.28 Figure VI-5 summarizes the non-accident spills for the period 1974 through 1981. This figure emphasizes the fact that a relatively large amount of oil has been released in a relatively small number of incidents.

6.29 Spill records show that there have been no spills of hazardous substances, other than petroleum products, resulting from vessel accidents during the period of this report. In addition, Tables VI-25 through VI-31 show there has been only a small amount of hazardous substances spilled as a result of other vessel operations. Table VI-27 shows a spill of 1 gallon of an unidentified hazardous substance. Table VI-28 shows a 5 gallon spill of paint. Table VI-29 shows a 10 gallon spill of coal tar. Table VI-30 shows a 10 gallon spill of an "other hazardous substance", a 1 gallon spill of paint, and a 10 gallon spill of paraffin wax. In all, the number of hazardous substance spills and the size of these spills has been small.

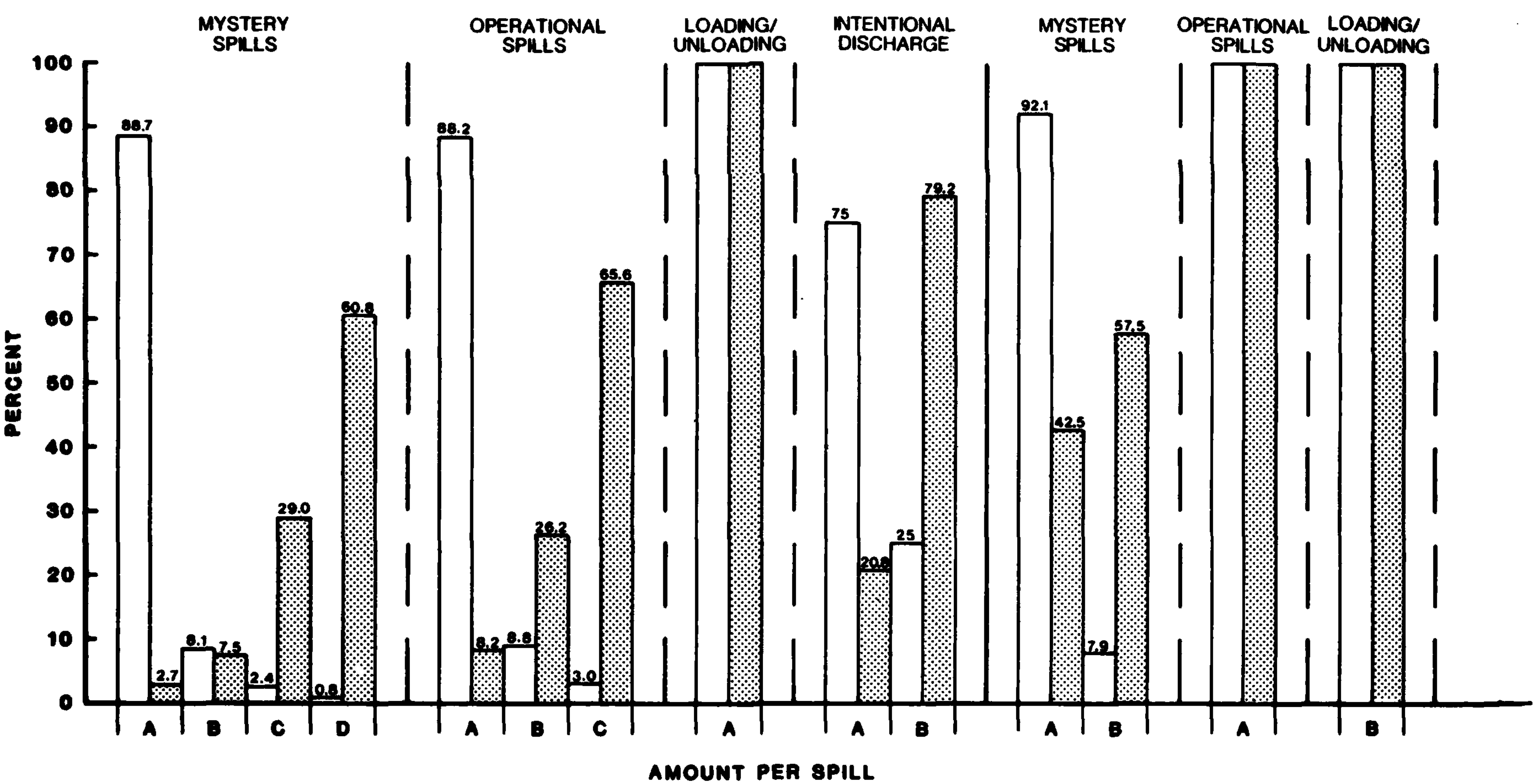
FIGURE VI-5 SUMMARY OF NON-ACCIDENT SPILLS, 1974-1981 (14)

PERCENT OF TOTAL AMOUNT SPILLED AND PERCENT OF TOTAL NUMBER OF SPILLS VS. SPILL SIZE

KEY:

	AMOUNT PER SPILL
A	< 100 GAL
B	100-999 GAL
C	1000-9999 GAL
D	≥ 10,000 GAL

(shaded)	% OF TOTAL AMOUNT SPILLED
(unshaded)	% OF TOTAL NUMBER OF SPILLS



VII. ASSESSMENT OF SPILL RISK

Method of Determining Spill Risk

7.01 A great many calculations are involved in determining the risk of a spill for this analysis, but the method is quite simple. The plan is to determine the probability of an accident and a spill for the normal navigation season, then use these results to determine the probability of an accident and spill in the various extended season alternatives based on the estimated number of transits that would occur in these seasons.

7.02 The basic variables used in making the computations are as follows:

P_A - probability that a ship has an accident

$P_{S/A}$ - probability of a spill, given an accident has occurred

P_S - probability of a spill

7.03 Probability of a Accident. The computational requirement is to determine the probability of an accident for a given number of extended season transits. Let N equal the number of transits and P_{Ai} the probability of an accident under different environmental conditions. It turns out that there are only two sets of environmental conditions that have been recorded and can be associated with vessel accidents in the St. Clair/ Detroit River System: these are good visibility and low visibility. Assume that there are N transits in an extended season and that n_G transits occur in good visibilty and n_L transits occur in low visibility. ($N = n_G + n_L$). Further, assume that P_{AG} is the probability that an accident occurs in good visibility and P_{AL} is the probability that an accident occurs in low visibility. Using these symbols, the probability that an accident does not occur in good visibility is $(1 - P_{AG})^{n_G}$ and the probability that an accident does not occur in low visibility is $(1 - P_{AL})^{n_L}$. The probability than an accident does not occur in both of these conditions is $(1 - P_{AG})^{n_G} (1 - P_{AL})^{n_L}$. The probability that an accident does occur in the first N transits where $N = n_G + n_L$ is therefore

(1) $$P_A = 1 - (1 - P_{AG})^{n_G} (1 - P_{AL})^{n_L} \qquad (22)$$

This is the basic relationship that is used in all of the computations that follow.

7.04 There are four kinds of accidents and associated probabilities for the St. Clair/Detroit River System:

P_{AG} - Probability of an Accident, Grounding

P_{AC} - Probability of an Accident, Collision

P_{ACI} - Probability of an Accident, Collision with Ice

P_{AGI} - Probability of an Accident, Grounding in Ice

It is assumed that the events described by these probabilities are entirely independent; that is, a grounding is entirely unrelated to a collision or a collision with ice. Although a single accident could possibly involve both a grounding and a collision, none have been recorded in the data available for the Great Lakes, therefore the probability of this event is assumed to be near zero. Based on the assumption that the events are independent, the probability of an accident is the probability that a grounding occurs, or the probability that a collision occurs, or the probability that a collision with ice occurs, or the probability that a grounding in ice occurs. Expressed in mathematical terms this becomes:

(2) $$P_A = P_{AG} + P_{AC} + P_{ACI} + P_{AGI}$$

7.05 Assume that a grounding or a collision can occur in any season but that a collision with ice can occur only during the time when ice is present. The probability of an accident can be computed as follows:

N = Total number of transits for the season

n_G = Transits in good visibility

n_L = Total transits in low visibility

$N = n_G + n_L$

n_I = transits in ice

Note: Because in this analysis all accidents in ice occurred in good visibiility, it is not necessary to divide transits in ice according to visibility conditions.

P_{AGG} = Probability of an accident, grounding, good visibility

P_{AGL} = Probability of an accident, grounding, low visibility

P_{ACI_t} = Probability of a collision with ice per transit

P_{AGI_t} = Probability of a grounding in ice per transit

Applying the additional subscripts G and L in a similar manner to indicate events that occur in good visibility and low visibility, the probability of an accident becomes:

$$P_{AG} = 1 - (1 - P_{AGG})^{n_G} (1 - P_{AGL})^{n_L}$$

$$P_{AC} = 1 - (1 - P_{ACG})^{n_G} (1 - P_{ACL})^{n_L}$$

$$P_{ACI} = 1 - (1 - P_{ACI_t})^{n_I}$$

$$P_{AGI} = 1 - (1 - P_{AGI_t})^{n_I}$$

Since the overall probability of an accident is given by:

$$P_A = P_{AG} + P_{AC} + P_{ACI} + P_{AGI}$$

the complete expression for the probabilty of an accident is

(3) $$\begin{aligned} P_A = & [1 - (1 - P_{AGG})^{n_G} (1 - P_{AGL})^{n_L}] + \\ & [1 - (1 - P_{ACG})^{n_G} (1 - P_{ACL})^{n_L}] + \\ & [1 - (1 - P_{ACI_t})^{n_I}] + \\ & [1 - (1 - P_{AGI_t})^{n_I}] \end{aligned}$$

7.06 Probability of a Spill. The probability of a spill is given by:

$$P_S = P_{S/A} \times P_A$$

where

$P_{S/A}$ = Probability of a spill, given an accident

P_A = Probability of an accident

Since the model provides for four kinds of accidents, there are also four kinds of spills; that is, a spill resulting from a grounding, a spill resulting from a collision, and a spill resulting from a collision with ice, and a spill resulting from a grounding in ice.

$P_{SG/AG}$ = Probability of a spill, grounding, given an accident, grounding

$P_{SC/AC}$ = Probability of a spill, collision, given an accident, collision

$P_{SCI/ACI}$ = Probability of a spill, collision with ice, given an accident, collision with ice

$P_{SGI/AGI}$ = Probability of a spill, grounding in ice, given an accident, grounding in ice

As in case of an accident, a spill can occur as a result of grounding, or a collision, or a collision with ice, or a grounding in ice. The probability of a spill then becomes:

$$(4) \quad P_S = P_{SG/AG} \times P_{AG} + P_{SC/AC} \times P_{AC} + P_{SCI/ACI} \times P_{ACI} + P_{SGI/AGI} \times P_{AGI}$$

Note that there is a single probability of a spill for each kind of accident because the chance of a spill once an accident has occurred does not depend on whether the accident occurred in good visibility or low visibility. Also, the probability of a spill resulting from a collision with ice is assumed to be the same as for a collision with a ship or fixed object. Further, the probability of a spill resulting from a grounding in ice is assumed to be the same as for a grounding in open water.

Computation of Spill Risk

7.07 Probability of An Accident, St. Clair River. Table VII-1 shows the probability of an accident on any single transit using records of the period 1974-1979. The number of accidents are recorded from Table VI-17 and the number of transits are recorded from Tables VI-8 and VI-9. The probability of an accident is (Number of Accidents)/(Number of Transits).

TABLE VII-1 PROBABILITY OF AN ACCIDENT, ST. CLAIR RIVER, 1974 - 1979

Assume that tankers and bulkers face the same hazard of an accident. This table, therefore, includes all accidents and transits.

		GROUNDINGS			COLLISION		COLLISION WITH ICE
		GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	
NUMBER OF ACCIDENTS		6	1	1	2	1	1
Number of	Tankers	5,062	120	239	5,062	120	239
Transits	Others	373,802	7,542	10,807	373,802	7,542	10,807
	Total	378,864	7,662	11,046	378,864	7,662	11,046
Probability of an Accident		0.0000158	0.000131	0.0000905	0.0000053	0.000131	0.0000905

7.08 Probability of a Tanker Accident and Spill During Extended Season Operations, St. Clair River. A sample computation will be performed showing the probability of a tanker accident and spill for the first extended season period for the St. Clair River. The probability of an accident is given by:

$$(3) \qquad P_A = [1 - (1 - P_{AGG})^{n_G} (1 - P_{AGL})^{n_L}] + [1 - (1 - P_{ACG})^{n_G} (1 - P_{ACL})^{n_L}] + [1 - (1 - P_{ACI_t})^{n_I}] + [1 - (1 - P_{AGI_t})^{n_I}]$$

From Table VI-14, the estimated number of additional tanker transits for the first extended season period (16 December - 15 January) are:

$$n_G = 13, \; n_L = 1, \; n_I = 3$$

From Table VII-1, the probabilities of the various categories of accident per transit are:

$$P_{AGG} = 0.0000158$$

$$P_{AGL} = 0.000131$$

$$P_{ACG} = 0.0000053$$

$$P_{ACL} = 0.000131$$

$$P_{ACI} = 0.0000905$$

$$P_{AGI} = 0.0000905$$

Substituting these values in equation (3), the numerical expression for the probability of an accident becomes:

$$\begin{aligned} P_A = {} & [1 - (1 - 0.0000158)^{13} (1 - 0.000131)^{1}] + && (P_{AG}) \\ & [1 - (1 - 0.0000053)^{13} (1 - 0.000131)^{1}] + && (P_{AC}) \\ & [1 - (1 - 0.0000905)^{3}] + && (P_{ACI}) \\ & [1 - (1 - 0.0000905)^{3}] && (P_{AGI}) \\ = {} & 0.0011 \end{aligned}$$

The results of this computation and each intermediate computation are shown on Table VII-2. The remaining columns in Table VII-2 are computed in the same way. That is, the additional number of transits estimated for each extended season are substituted in equation (3) with the probabilities of the various categories of accidents per transit shown above, to compute the probability of an accident for that extended season period. A computation is also made to determine the probability of an accident in a single normal season. The normal season is defined as one having transits equal to the average number of transits that occurred over the period 1974-1979.

7.09 The prcbability of an accident for Lake St. Clair and the Detroit River are computed in the same way. First the probability of an accident per transit is computed based on the historical records of accidents and transits over the period 1974-1979. These results are shown on Tables VII-3 and VII-5. Next, the estimated number of transits for each extended season period are used in equation (3) with these probabilities of accident per transit to compute the probability of an accident for each section of the waterway in the proposed extended seasons. The results of these computations are shown in Tables VII-4 and VII-7.

7.10 Probability of a Spill, Given an Accident, St. Clair River. The probability of a spill given an accident is computed by dividing the number of spills resulting from accidents by the number of accidents for a period of time covered by historical records. Since there are no spills resulting from ship accidents recorded for the St. Clair River during the years included in this analysis, it is necessary to obtain data from a broader area. The probability of a spill given an accident was computed for the entire Great Lakes area in a similar study performed for the Corps of Engineers (23). Because one can argue that the probability of a spill given an accident has occurred is not area dependent, the values determined for all of the Great Lakes will now be applied to the St. Clair River. In addition, assume that the probability of a spill resulting from a collision with ice is the same as the probability of a spill resulting from any other collision, and that the probability of a spill resulting from a grounding in ice is the same as the probability of a spill resulting from any other grounding. The values shown below for the probability of a spill given a collision has occurred and the probability of a spill given a grounding has occurred were determined in the earlier study for all the Great Lakes:

$$P_{SC/AC} = P_{SCI/ACI} = 0.048 \quad (23)$$

$$P_{SG/AG} = P_{SGI/AGI} = 0.111 \quad (23)$$

7.11 Probability of a Spill, St. Clair River. A sample computation will be performed showing the probability of a tanker spill for the St. Clair River in the first extended season period using the probability of an accident shown in Table VII-2 and the probability of a spill given an accident determined earlier for the entire Great Lakes area. Using equation (4):

$$(4) \quad P_S = P_{SG/AG} \times P_{AG} + P_{SC/AC} \times P_{AC} + P_{SCI/ACI} \times P_{ACI} + P_{SGI/AGI} \times P_{AGI}$$

and numerical results determined previously,

$$P_S = (0.111 \times .00034) + (0.048 \times 0.00027) + (0.048 \times 0.00027) + (0.111 \times 0.00027)$$

$$P_S = 0.00009$$

The computation is performed in a similar way for the probability of a spill for the remaining four extended season periods and the normal season. The results of these computations for the probability of a spill are shown on Table VII-2.

7.12 Probability of a Spill, Lake St. Clair. Since there have been no spills resulting from accidents in Lake St. Clair during the years covered in this analysis, it will be assumed that the probability of a spill given an accident is the same as for the entire Great Lakes area. Using these values, and the probability of an accident shown in Table VII-4, the probability of a spill for the extended seasons and the normal season are computed for Lake St. Clair and recorded on Table VII-4.

7.13 Probability of a Spill, Given an Accident, Detroit River. There were three spills resulting from collisions on the Detroit River during the period of time covered in this analysis. The probability of a spill given an accident occurred is shown on Table VII-6. Since there were no spills resulting from a grounding, the experience for all the Great Lakes is assumed as before.

TABLE VII-2 PROBABILITY OF A TANKER ACCIDENT AND SPILL DURING EXTENDED SEASON OPERATIONS, ST. CLAIR RIVER

EXTENDED SEASON		ADDITIONAL DAYS
1	16 December to 15 January	31
2	16 December to 14 February	61
3	25 March to 1 April	4
4	18 March to 1 April	14
5	16 December to 1 April	106
Normal	1 April to 15 December	259

SEASON	1	2	3	4	5	NORMAL Average Annual Transits
ADDITIONAL TRANSITS						
Good Visibility	13	22	3	5	39	844
Low Visibility	1	2	0	0	2	20
Ice	3	6	0	1	8	40
PROBABILITY ACCIDENT						
P_{AG}	0.00034	0.00061	0.000047	0.000079	0.00088	0.016
P_{AC}	0.0002	0.00038	0.000016	0.000026	0.00047	0.0071
P_{ACI}	0.00027	0.00054	0	0.000091	0.00072	0.0036
P_{AGI}	0.00027	0.00054	0	0.000091	0.00072	0.0036
P_A	0.0011	0.0021	0.00063	0.00029	0.0028	0.03
PROBABILITY SPILL						
P_{SG}	0.00004	0.00007	0.000005	0.000009	0.0001	0.0018
P_{SC}	0.00001	0.00002	0.0000008	0.000001	0.00002	0.0003
P_{SCI}	0.00001	0.00003	0	0.000004	0.00004	0.00018
P_{SGI}	0.00003	0.00006	0	0.00001	0.00008	0.0004
P_S	0.00009	0.0002	0.000006	0.00002	0.0002	0.0027

TABLE VII-3 PROBABILITY OF AN ACCIDENT, LAKE ST. CLAIR, 1974 - 1979

Assume that tankers and bulkers face the same hazard of an accident. This table, therefore, includes all accidents and transits.

		GROUNDINGS			COLLISION		COLLISION WITH ICE
		GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	
NUMBER OF ACCIDENTS		6	3	4	2	0	1
Number of Transits	Tankers	2,956	65	288	2,956	65	288
	Others	55,276	969	1,664	55,276	969	1,664
	Total	58,232	1,034	1,952	58,232	1,034	1,952
Probability of an Accident		0.000103	0.0029	0.0020	0.00003	0	0.00051

TABLE VII-4 PROBABILITY OF A TANKER ACCIDENT AND SPILL DURING EXTENDED SEASON OPERATIONS, LAKE ST. CLAIR

EXTENDED SEASON		ADDITIONAL DAYS
1	16 December to 15 January	31
2	16 December to 14 February	61
3	25 March to 1 April	4
4	18 March to 1 April	14
5	16 December to 1 April	106
Normal		

SEASON	1	2	3	4	5	NORMAL
ADDITIONAL TRANSITS						Average Annual Transits
Good Visibility	6	10	1	2	17	493
Low Visibility	1	2	0	0	2	11
Ice	3	6	0	1	9	48
PROBABILITY ACCIDENT						
P_{AG}	0.0035	0.007	0.0001	0.00021	0.0075	0.079
P_{AC}	0.0002	0.0003	0.00003	0.00006	0.00051	0.015
P_{ACI}	0.0015	0.003	0	0.00051	0.0046	0.024
P_{AGI}	0.006	0.012	0	0.002	0.018	0.092
P_A	0.011	0.022	0.00013	0.0028	0.030	0.21
PROBABILITY SPILL						
P_{SG}	0.00039	0.00078	0.00001	0.00002	0.00083	0.009
P_{SC}	0.00001	0.00001	0.000001	0.000003	0.00002	0.0007
P_{SCI}	0.00007	0.00014	0	0.00003	0.00022	0.0012
P_{SGI}	0.00067	0.00133	0	0.00022	0.002	0.0102
P_S	0.0011	0.0023	0.00001	0.00027	0.0031	0.021

TABLE VII-5 PROBABILITY OF AN ACCIDENT, DETROIT RIVER, 1974 - 1979

Assume that tankers and bulkers face the same hazard of an accident. This table, therefore, includes all accidents and transits.

		GROUNDINGS			COLLISION		COLLISION WITH ICE
		GOOD VIS.	LOW VIS.	ICE	GOOD VIS.	LOW VIS.	
NUMBER OF ACCIDENTS		14	0	4	60	1	11
Number of Transits	Tankers	6,717	159	521	6,717	159	521
	Others	84,839	1,663	3,364	84,839	1,663	3,364
	Total	91,556	1,822	3,885	91,556	1,822	3,885
Probability of an Accident		0.000153	0	0.0010	0.00066	0.00055	0.0028

TABLE VII-6 PROBABILITY OF A SPILL RESULTING FROM A VESSEL ACCIDENT, DETROIT RIVER, 1974-1979

	GROUNDING	COLLISION
Number of Spills	0	3
Number of Accidents	18	72
$P_{S/A}$		0.042

$P_{S/A}$ - Probability of a spill, given an accident has occurred.

7.14 Probability of a Spill, Detroit River. The probability of a spill given a collision in the Detroit River was found to be 0.042. Assuming that the probability of a spill from a collision with ice is the same as other collisions:

$$P_{SC/AC} = P_{SCI/ACI} = 0.042$$

Assuming that the probability of a spill from a grounding is the same as for all the Great Lakes and that the probability of a spill from a grounding in ice is the same as for all other groundings:

$$P_{SG/AG} = P_{SGI/AGI} = 0.111$$

The results of the computations for the probability of a spill for the Detroit river are shown on Table VII-7.

Assessment of Computational Results

7.15 St. Clair River. Computational results for the St. Clair River are strongly affected by the very large number of annual transits reported for the River. Table VII-1 shows that there are 386,526 transits reported for the St. Clair River (good visibility plus low visibility) for the six year period of the study, but for Lake St. Clair, there are only 59,266 transits in the same period of time. Because there are no ports on Lake St. Clair, the generally accepted rule of thumb is that most major commercial vessels pass through the St. Clair River/Lake St. Clair waterway and therefore the number of transits in these two channels is expected to be the same (24). Because the recorded transits in the St. Clair river are more than six times larger than recorded transits in Lake St. Clair, there appears to be a discrepancy between recorded data and operational experience. A quick check of annual transit data in a recent copy of "Waterborne Commerce of the United States" (Part 3) will help to explain what appears to be an inconsistency (25). For example, on pages 84 and 85 of the 1979 edition, transits for passenger and dry cargo vessels with drafts of 13 to 30 feet are nearly identical for the St. Clair River and Lake St. Clair. For drafts of 12 feet and less, however, the St. Clair River shows 56,791 transits upbound and downbound while Lake St. Clair shows 104. Clearly there is an extremely high level of shallow draft vessel activity in the St. Clair River that does not occur at other locations in the system. This activity may be railroad car ferries operating between Port Huron and Sarnia, or some other local industrial traffic.

TABLE VII-7 PROBABILITY OF A TANKER ACCIDENT AND SPILL DURING EXTENDED SEASON OPERATIONS, DETROIT RIVER

EXTENDED SEASON		ADDITIONAL DAYS
1	16 December to 15 January	31
2	16 December to 14 February	61
3	25 March to 1 April	4
4	18 March to 1 April	14
5	16 December to 1 April	106
Normal		

SEASON	1	2	3	4	5	NORMAL
ADDITIONAL TRANSITS						Average Annual Transits
Good Visibility	15	27	3	6	46	1,120
Low Visibility	2	3	0	0	4	27
Ice	4	11	0	1	15	87
PROBABILITY ACCIDENT						
P_{AG}	0.002	0.004	0.0004	0.0009	0.007	0.16
P_{AC}	0.011	0.02	0.002	0.004	0.032	0.53
P_{ACI}	0.011	0.03	0	0.0028	0.041	0.22
P_{AGI}	0.004	0.011	0	0.001	0.015	0.08
P_A	0.028	0.065	0.002	0.0087	0.095	0.99
PROBABILITY SPILL						
P_{SG}	0.0002	0.0004	0.00004	0.0001	0.0008	0.018
P_{SC}	0.0005	0.0008	0.00008	0.0002	0.001	0.022
P_{SCI}	0.0005	0.0013	0	0.0001	0.002	0.009
P_{SGI}	0.0004	0.0012	0	0.0001	0.002	0.009
P_S	0.002	0.004	0.0001	0.0005	0.006	0.06

7.16 Whatever the cause, the high number of vessel transits in the St. Clair River together with a near-normal vessel accident rate has the effect of making the probability of an accident per transit very low. This is evident in the results for probability of an accident in Table VII-1. This low level of risk per transit carries over into the predicted probabilities of an accident and a spill in the extended season options and in the average normal season shown on Table VII-2. The probability of an accident for each extended season is very low based on a fairly small number of additional transits expected in these seasons. The probability of a spill in the shortest extended seasons, 1, 3, and 4, is very small while the probability of a spill in the longer seasons 2 and 5 is still very low but nearly equal despite a fairly large difference in the number of transits. The probability of a spill in the average normal season is also quite low.

7.17 Based on these results, there is some temptation to remove the transits of vessels with drafts of 12 feet or less from the data so that the results of risk computations are more "normal", or closer to results for other similar channels in the Great Lakes Waterways System. This action could perhaps be justified on the premise that the St. Clair River has a high level of local small-vessel traffic that does not occur, or is not reported, elsewhere in the system. An equally strong argument can be made for the fact that this high level of local traffic does occur and is certain to present some hazard to navigation for through commercial traffic. Whether the hazard of shallow draft local traffic is less than, equal to, or greater than the hazard presented by the through traffic is not known and cannot adequately be determined in this study. As a result, transit records will not be adjusted but rather analyzed just as they were reported. To provide the reader with a good picture of a more typical channel in this waterway system, a detailed analysis will be performed on the data developed for Lake St. Clair. This is a more "normal" channel since most reported transits are of through traffic of commercial carriers.

7.18 Lake St. Clair. Table VII-3 shows that the transits recorded for Lake St. Clair are more typical of Great Lakes Waterway channels. The probability of an accident per transit is still quite low, but when this result is used in the spill risk model to compute the probability of an accident in an average normal season, the result follows real world experience quite well. For example, Table VI-18 shows that there have been 2 tanker accidents in the 6 years covered in accident records. This means that the probability of a tanker accident is roughly .3 in a single year, which agrees reasonably well with the computed value of .2 for an average season shown on Table VII-4. The probability of a spill in a normal season is still fairly low, .02, which means there is roughly 1 chance in 50 that a tanker will have an accident that results in a spill during normal season operations. The probability of a spill in the additional transits during extended season operations is also low, .003 for the full extended season. This means there is a chance of about 1 in 300 of a spill during full extended season operations. The probability of a spill for each of the other extended season periods is much lower.

7.19 Consider now the question of how many years will pass before the probability of an accident for Lake St. Clair is very high. This can be estimated by solving equation (3) several times using Lake St. Clair accident risk data and a cumulative number of transits from 1 to 6 years. The results of these computation are shown below. These results show that by the fifth year the probability of an accident is very high

Year	P_A
1	0.12
2	0.40
3	0.55
4	0.75
5	0.91
6	1.05

and between the fifth and sixth year an accident is almost certain to occur. Using the computed probabilities of an accident for the normal season over a five year period, the probability of a spill in this same 5 year period is 0.09. This means that in 5 years, there is roughly a 1 in 10 chance of a spill resulting from a tanker accident during the normal season.

7.20 Finally consider the probability of an accident and a spill over a five year period for the extra transits that occur during full season extension, that is season 5. Over 5 years of full season extension the probability of an accident in one of the additional transits is 0.15 and the probability of a spill is 0.015. This means that there is roughly a 1 in 70 chance of a tanker spill resulting from an accident during five years of full season extension.

7.21 Detroit River. The Detroit River is a busy industrial waterway with a relatively high number of vessel transits and a fairly high number of accidents (Table VII-5). The number of collisions may seem to be fairly high, but a great many of these accidents are bumps and scrapes with piers and other vessels that occur in narrow turning basins adjacent to industrial plants. Most important, the collisions do not involve major hull damage that may result in an oil spill. Table VII-6 shows that there have been three oil spills resulting from collisions, two involving tankers and one involving a tug, but in each case the spill was 10 gallons or less. Using all three of these spills, the probability of a spill given an accident (0.042) is close to the experience for tank ships in all the Great Lakes (0.048) determined in an earlier Corps of Engineers study (23).

7.22 Table VII-7 shows that the probability of a tank ship accident in the Detroit river in a single normal season is nearly one. This agrees with historical records because there have been 8 tank ship spills in a period of 6 years, which is an average of more than one per year. The probability of a spill computed for a single average year (0.06) is somewhat low in that there have been two tanker spills and one tug spill in a six year period. On the other hand, three spills is a small number to identify a statistical trend, so that over a much longer period of time, the number of spills that occur may be much smaller. Table VII-7 shows that the probability of a spill during the extended season periods is, in every case, very small. This indicates that there is a low risk of a spill because of extended season operations in any single year.

7.23 Now consider the probability of a tanker accident and spill in the extra transits expected to occur in full season extension (season 5) in a period of 5 years. Using the total additional transits that would occur in equations (3) and (4), it is found that the probability of a tanker accident in this period of time would be .45 and the probability of a spill would be 0.03. This means that there is about 1 chance in 30 of a spill during full extended season operations in the Detroit River in a 5 year period.

7.24 Likely Size of a Spill. It would be helpful to be able to compute the expected size of a tanker spill based on spill records and the computed probability that a spill will occur. In statistics, "expected value" is a measure of central tendency of a probability distribution. It is calculated by taking the weighted average of all possible values of a random variable, or in other words, by multiplying each value by its probability of occurrence then summing the resulting products (22). The problem in applying this concept to the present analysis is that the probability distribution must sum to one. In the case at hand, the complete probability distribution is not known and the values of the random variable, in this case spill size, are only known for the Detroit River, but not for the St. Clair River or Lake St. Clair. Because of the limitation of data that are available, it is not possible to compute a true expected value for spill size.

7.25 In spite of these problems, it would still be desirable to define a measure of effectiveness that would show how much oil could be expected to be spilled for various season extension alternatives based on both spill records and the probability of a spill. The measure used in this analysis will be called the "likely size" of a spill to differentiate if from the statistical "expected value". The likely size of a spill can be computed after defining the following variables:

S_G = Average spill size, grounding
S_C = Average spill size, collision
P_{SG} = Probability of a spill, grounding
P_{SC} = Probability of a spill, collision
P_{SCI} = Probability of a spill, collision with ice

(There is no recorded spill resulting from a grounding in ice.)

then

$$\text{Likely Spill Size} = P_{SG} \times S_G + P_{SC} \times S_C + P_{SCI} \times S_C$$

Since the largest reported spill resulting from a vessel accident in the St. Clair River/Detroit River System is 10 gallons (Table VI-24), the likely size of a spill based on this maximum would be insignificant. To develop the worst case for the likely size of a spill, consider the average spill size using data taken from all of the Great Lakes for the period 1974-1979. An earlier study performed for the Corps of Engineers showed that average spill size for all the Great Lakes for a grounding is 74,589 gallons and the average size for a collision is 50 gallons. The spill size for a grounding is quite large and is based on several severe grounding accidents that occurred in other sections of the Lakes. Although this size spill does not apppear to be typical of the St. Clair River/ Detroit River System, it will be considered to represent a worst case situtation for the entire area. Using the expressions developed above, the likely spill size for Lake St. Clair in normal season operations is given by the following:

Likely Spill Size = 0.009 x 74,589 + 0.0007 x 50 + 0.0012 x 50

Taking each element of this computation separately, the result becomes:

Likely Spill Size, Normal Season (gallons)

Grounding	671.3
Collision	0
Collision with ice	0.1
	671.4

This computation shows that the likely amount of oil discharged from a spill during the normal season is small, even considering a worst case spill situation, and that the chief threat of a significant discharge is a vessel grounding. If an average spill size for the Detroit River were used, that is, 8 gallons, the likely spill size would be less than a tenth of a gallon.

7.26 Increased Risk in the Extended Season. Although the probability of a spill during extended season operations is very low, it would be useful to establish some measure of increased risk that may occur during the extended season. Consider as a measure of the risk, the probability of an accident per transit and the probability of a spill per transit. These values are shown on Table VII-8. The probability of an accident and spill per transit are averaged over the five extended seasons. These ratios are then divided by the probability of an accident and a spill per transit for the normal season. The results of this division (average/normal) show that although the probability of an accident or a spill per transit is very low, the ratios for the St. Clair River and the Detroit River are 1.5 to 2 times greater than the normal seson, and the probability of an accident and spill is more than 5 times greater in Lake St. Clair during the extended seasons. This increased risk is largely due to operating in ice.

7.27 Confidence Intervals for Probability of an Accident and a Spill. A number of tests can be performed to estimate a level of confidence in computing the probability of a chance event. These tests generally require that the number of trials or observations be large and that the probability of the event not

TABLE VII-8 PROBABILITY OF AN ACCIDENT OR SPILL PER TRANSIT

SEASON	ST. CLAIR RIVER P_A/Transit ($x\ 10^{-5}$)	ST. CLAIR RIVER P_S/Transit ($x\ 10^{-6}$)	LAKE ST. CLAIR P_A/Transit ($x\ 10^{-3}$)	LAKE ST. CLAIR P_S/Transit ($x\ 10^{-4}$)	DETROIT RIVER P_A/Transit ($x\ 10^{-3}$)	DETROIT RIVER P_S/Transit ($x\ 10^{-4}$)
1	7.9	6.4	1.6	1.6	1.6	1.2
2	8.8	8.3	1.8	1.9	2.2	1.3
3	2.1	2.0	0.1	0.1	0.7	0.3
4	5.8	4.0	1.4	1.4	1.5	0.8
5	6.8	4.9	1.6	1.6	1.9	1.2
AVERAGE	6.3	5.1	1.3	1.3	1.6	0.96
NORMAL	3.5	3.1	0.24	0.24	0.86	0.52
AVERAGE/NORMAL	1.8	1.6	5.4	5.4	1.9	1.8

be too close to zero or 1. Many of the probabilities computed in this analysis are close to zero, but observations can still be made about confidence intervals.

7.28 First consder the probability of an accident in the St. Clair River shown in Table VII-1. The probability of grounding in good visibility approaches zero, therefore the standard mathematical test for confidence interval cannot be applied. However, size of the population observed, 378,846, does in itself provide a level of confidence in the result. In this large sample there are only six accidents in six years. The reader can easily be persuaded that small changes in the number of accidents reported in some other interval of time would have only a small effect on the probability of an accident. For example, if in another six year period there were 10% more accidents, that is, 7 instead of 6, then the probability of an accident for the same number of transits would be 0.0000185, which is very close to the result in this analysis. This same arguement can also be made for the probability of an accident in Lake St. Clair and the Detroit River. It is possible to conclude, then, that the probability of an accident for a large number of transits is quite accurate because a moderate change in the number of accidents would cause only a small change in the result.

7.29 Now consider the probability of other events that are not either very close to zero or one, and are based on a smaller number of events. Referring to Table VII-4, the probability of an accident in a normal season for Lake St. Clair is computed to be 0.21, which is not close to zero and is based on a fairly large sample size. The confidence interval can therefore be checked using a standard test. The 90% confidence interval is given by:

$$1.64\sqrt{\frac{P(1-P)}{N}} \qquad (26)$$

where P is the probability of the event and N is the sample size. With P = 0.21 and N = 493 tanker transits per year, the results is 0.04. That is, one can be 90% confident that the probability of an accident in a normal season is between 0.25 and 0.17.

7.30 For the same situation, normal season operations in Lake St. Clair, consider the confidence limits for the probability of a spill, which is 0.021. Using the same expression and assuming N = 493, the result is 0.01. This means it is possible to be 90% confident that the result is between 0.031 and 0.011. Now the interval is much broader as a percent of the original value. This computation would not be suitable for the probability of an accident and spill for the extended season periods in Lake St. Clair because these values are very close to zero and the number of transits (N) is also quite low.

7.31 In the Detroit River, the probability of a spill for normal season operations is the only probability that is not close to zero and based on a population size that is large enough to compute a confidence interval. Using the probability of a spill of 0.06 and N = 1120, the computed confidence interval is 0.01. This means that you can be 90% certain that the probability of a spill is 0.05 to 0.07.

VIII. CONCLUSIONS

Probability of an Accident and Spill

8.01 The probability of a spill resulting from a vessel accident in the St. Clair/Detroit River Waterway System is low. During the time covered by accident and spill records (1974 - 1979), there have been no spills resulting from accidents in the St. Clair River and Lake St. Clair, and three spills resulting from accidents in the Detroit River. Table VIII-1 summarizes the probabilities of an accident and a spill for an average normal season and for the additional transits that would occur during a full season extension for each segment of the St. Clair/Detroit River Waterway System.

TABLE VIII - 1 TANKER ACCIDENT AND SPILL SUMMARY

	AVERAGE NORMAL SEASON	FULL SEASON EXTENSION
St. Clair River		
P_A	0.03	0.003
P_S	0.003	0.0002
Lake St. Clair		
P_A	0.2	0.03
P_S	0.02	0.003
Detroit River		
P_A	0.99	0.10
P_S	0.06	0.006

8.02 Although the probability of an accident and a spill are low during the extended season periods, the threat of an accident or a spill per transit during late season operations is from two to five times greater than in a normal season.

Operational Assessment

8.03 Senior U.S. Coast Guard officers responsible for safe navigation in the St. Clair/Detroit River System believe that winter operations can be expected to be relatively safe. Ice conditions may make navigation somewhat more difficult, but operations can continue and there is very little danger of holing a ship because of a collision with ice. Ice jams may temporarily stop navigation, but they can generally be cleared by icebreakers. Accumulations of slush may also halt navigation, however the slush clears quickly in strong currents.

General Conclusions

8.04 The St. Clair/Detroit River Waterway is nearly a full season system now. Although bulker traffic decreases appreciably in the winter, tanker traffic continues with a much smaller seasonal reduction. Increasing winter operations with icebreaker support is expected to have a negligible affect on the threat of a spill.

8.05 Oil spills resulting from vessel accidents in the St. Clair/Detroit River System are small in number and small in size. There were no spills caused by accidents in either the St. Clair River or Lake St. Clair during the period of this study. In the Detroit River, there were three spills resulting from accidents that released a total of 25 gallons of oil in the six year period covered in this study. In that same six year period, there were 247 unreported spills that released 66,600 gallons of oil. This means that the number of unreported spills is larger than accident spills by a factor of 82 and the quantity of oil spilled is larger by a factor of 2700.

IX. RECOMMENDATIONS

9.01 Valuable planning information can be obtained by using records of vessel operations to determine the threat of an oil spill in critical shipping choke points. Because recent records provide the best data base for predicting future trends, it is recommended that the data required to predict these trends be collected on a continuing basis. Further, it is recommended that new computations of spill threat be made periodically to assess the impact of changes in traffic levels and operating practices.

9.02 Because only a small number of accidents and spills occur in any one segment of the Great Lakes Waterway System, the population of data for a single area is often too small to develop a high level of confidence in the computed threat of an accident or a spill. A fairly large number of accidents and spills do occur in the Great Lakes Basin, however the results of studies of small segments of the System do not expose this experience. In order to use all of the information available in the entire system, it is recommended that tanker traffic be studied for the entire Great Lakes area and the threat of a spill be determined using annual reports of vessel transits and spills. This analysis would produce the highest possible accuracy of the probability of an accident and a spill since it would cover the entire range of Great Lakes experience. In addition, the study would also produce the most accurate information on the expected size of spills because the records of all spills would be included.

9.03 It is recommended that adequate steps be taken to improve oil spill surveillance and enforcement because unreported spills are, by far, the most numerous and largest spills that occur in the waterway system.

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APPENDIX A

TRANSIT DATA FOR
ST. CLAIR RIVER, LAKE ST. CLAIR AND
DETROIT RIVER, 1974-1980

Compiled by

Department of the Army
Water Resources Support Center
Corps of Engineers
Waterborne Commerce Statistics Center

DEPARTMENT OF THE ARMY
WATER RESOURCES SUPPORT CENTER
CORPS OF ENGINEERS
WATERBORNE COMMERCE STATISTICS CENTER
P.O. BOX 61280
NEW ORLEANS, LOUISIANA 70161

IN REPLY REFER TO:

WRSC-CC

25 October 1982

Mr. Robert H. Schulze
ARCTEC, Inc.
9104 Red Branch Road
Columbia, Maryland 21045

Dear Mr. Schulze:

This is in reference to your letter dated 20 August 1982, with regard to your special request for waterborne statistics on the Detroit River, channels in Lake St. Clair and the St. Clair River.

The vessel trip information is provided for calendar years 1974 - 1980 for the Detroit River (Incl 1), Channels in Lake St. Clair (Incl 2) and St. Clair River (Incl 3). The vessels included in Group-1 are self-propelled tanker vessels and tanker barges. The vessels included in Group-2 are all other vessels.

For calendar years 1977 - 1978 the vessel trips given in Inclosure 3 will not agree with the trip and draft statistics given in the publication, "Waterborne Commerce of the United States (WCUS)" for those years because the statistics given in the WCUS publications have been updated since the documents were published.

We will request our Finance and Accounting office to bill you for $2,500.00 to cover the cost of preparation of the reports.

If this office can be of any further assistance, please feel free to call or write.

for Pierre J. Andrus

DAVID L. PENICK
Chief, Waterborne Commerce
Statistics Center

3 Incls
1. Detroit River
2. Lake St. Clair
3. St. Clair River

ST. CLAIR RIVER, MICHIGAN (3501)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1974	JAN	31	3,126	3,157
1974	FEB	40	2,194	2,234
1974	MAR	42	3,398	3,440
1974	APR	54	5,303	5,357
1974	MAY	43	6,122	6,165
1974	JUN	47	6,487	6,534
1974	JUL	43	6,721	6,764
1974	AUG	64	6,820	6,884
1974	SEP	81	6,414	6,495
1974	OCT	63	6,134	6,197
1974	NOV	80	5,417	5,497
1974	DEC	80	4,829	4,909
1974	ANN	105	232	337
		773	63,197	63,970

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

ST. CLAIR RIVER, MICHIGAN (3501)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1975	JAN	77	3,867	3,944
1975	FEB	62	2,611	2,673
1975	MAR	56	2,974	3,030
1975	APR	62	4,359	4,421
1975	MAY	90	5,765	5,855
1975	JUN	93	6,726	6,819
1975	JUL	81	7,346	7,427
1975	AUG	85	6,373	6,458
1975	SEP	73	5,864	5,937
1975	OCT	85	5,957	6,042
1975	NOV	40	6,480	6,520
1975	DEC	49	3,896	3,945
1975	ANN	66	1,658	1,724
		919	63,876	64,795

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

ST. CLAIR RIVER, MICHIGAN (3501)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1976	JAN	61	1,522	1,583
1976	FEB	61	2,046	2,107
1976	MAR	75	4,330	4,405
1976	APR	82	5,833	5,915
1976	MAY	76	6,128	6,204
1976	JUN	64	6,852	6,916
1976	JUL	75	7,425	7,500
1976	AUG	57	7,043	7,100
1976	SEP	68	6,310	6,378
1976	OCT	83	6,306	6,389
1976	NOV	73	5,748	5,821
1976	DEC	62	4,350	4,412
1976	ANN	25	2,707	2,732
		862	66,600	67,462

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

ST. CLAIR RIVER, MICHIGAN (3501)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1977	JAN	47	644	691
1977	FEB	41	2,393	2,434
1977	MAR	51	4,391	4,442
1977	APR	72	4,712	4,784
1977	MAY	74	6,105	6,179
1977	JUN	80	6,139	6,219
1977	JUL	76	7,327	7,403
1977	AUG	67	7,207	7,274
1977	SEP	73	4,830	4,903
1977	OCT	58	5,398	5,456
1977	NOV	64	5,054	5,118
1977	DEC	68	4,516	4,584
1977	ANN	25	3,375	3,400
		796	62,091	62,887

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

ST. CLAIR RIVER, MICHIGAN (3501)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1978	JAN	61	1,898	1,959
1978	FEB	53	2,651	2,704
1978	MAR	51	3,485	3,536
1978	APR	65	4,765	4,830
1978	MAY	73	5,600	5,673
1978	JUN	77	5,749	5,826
1978	JUL	103	6,285	6,388
1978	AUG	97	6,066	6,163
1978	SEP	81	6,469	6,550
1978	OCT	73	6,510	6,583
1978	NOV	68	3,253	3,321
1978	DEC	69	2,888	2,957
1978	ANN	19	3,344	3,363
		890	58,963	59,853

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

ST. CLAIR RIVER, MICHIGAN (3501)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1979	JAN	47	1,576	1,623
1979	FEB	49	2,110	2,159
1979	MAR	41	4,412	4,453
1979	APR	71	5,230	5,301
1979	MAY	85	9,113	9,198
1979	JUN	75	3,793	3,868
1979	JUL	89	7,095	7,184
1979	AUG	106	6,992	7,098
1979	SEP	84	6,535	6,619
1979	OCT	79	6,491	6,570
1979	NOV	89	5,570	5,659
1979	DEC	104	4,725	4,829
1979	ANN	23	2,975	2,998
		942	66,617	67,559

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

ST. CLAIR RIVER, MICHIGAN (3501)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1980	JAN	86	4,135	4,221
1980	FEB	30	3,048	3,078
1980	MAR	54	6,233	6,287
1980	APR	70	2,315	2,385
1980	MAY	80	6,056	6,136
1980	JUN	80	6,407	6,487
1980	JUL	82	5,894	5,976
1980	AUG	81	6,893	6,974
1980	SEP	98	3,002	3,100
1980	OCT	99	5,906	6,005
1980	NOV	110	3,097	3,207
1980	DEC	31	2,524	2,555
1980	ANN		589	589
		901	56,099	57,000

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

CHANNELS IN LAKE ST. CLAIR (3401)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1974	JAN	18	71	89
1974	FEB	11	12	23
1974	MAR	19	78	97
1974	APR	27	611	638
1974	MAY	23	940	963
1974	JUN	27	912	939
1974	JUL	21	959	980
1974	AUG	39	868	907
1974	SEP	40	942	982
1974	OCT	38	934	972
1974	NOV	39	919	958
1974	DEC	62	708	770
1974	ANN *	76	2,111	2,187
		440	10,065	10,505

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

CHANNELS IN LAKE ST. CLAIR (3401)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1975	JAN	29	129	158
1975	FEB	26	33	59
1975	MAR	22	59	81
1975	APR	32	491	523
1975	MAY	56	864	920
1975	JUN	68	866	934
1975	JUL	49	829	878
1975	AUG	43	775	818
1975	SEP	52	706	758
1975	OCT	67	766	833
1975	NOV	31	614	645
1975	DEC	27	449	476
1975	ANN	56	2,505	2,561
		558	9,086	9,644

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

CHANNELS IN LAKE ST. CLAIR (3401)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1976	JAN	26	84	110
1976	FEB	23	28	51
1976	MAR	34	57	91
1976	APR	53	460	513
1976	MAY	54	838	892
1976	JUN	46	829	875
1976	JUL	53	860	913
1976	AUG	38	832	870
1976	SEP	51	797	848
1976	OCT	58	785	843
1976	NOV	46	733	779
1976	DEC	35	377	412
1976	ANN	17	2,589	2,606
		534	9,269	9,803

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

CHANNELS IN LAKE ST. CLAIR (3401)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1977	JAN	18	36	54
1977	FEB	16	48	64
1977	MAR	44	68	112
1977	APR	47	407	454
1977	MAY	56	844	900
1977	JUN	56	868	924
1977	JUL	48	848	896
1977	AUG	43	640	683
1977	SEP	50	492	542
1977	OCT	34	440	474
1977	NOV	45	405	450
1977	DEC	44	438	482
1977	ANN	21	2,766	2,787
		522	8,300	8,822

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

CHANNELS IN LAKE ST. CLAIR (3401)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1978	JAN	25	167	192
1978	FEB	20	28	48
1978	MAR	9	49	58
1978	APR	36	394	430
1978	MAY	57	803	860
1978	JUN	49	808	857
1978	JUL	74	903	977
1978	AUG	61	863	924
1978	SEP	56	813	869
1978	OCT	47	810	857
1978	NOV	40	738	778
1978	DEC	33	567	600
1978	ANN	17	3,252	3,269
		524	10,195	10,719

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

CHANNELS IN LAKE ST. CLAIR (3401)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1979	JAN	14	111	125
1979	FEB	9	20	29
1979	MAR	22	43	65
1979	APR	34	329	363
1979	MAY	50	756	806
1979	JUN	49	797	846
1979	JUL	42	825	867
1979	AUG	33	822	855
1979	SEP	30	783	813
1979	OCT	43	811	854
1979	NOV	45	700	745
1979	DEC	49	441	490
1979	ANN	23	2,892	2,915
		443	9,330	9,773

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

CHANNELS IN LAKE ST. CLAIR (3401)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1980	JAN	28	24	52
1980	FEB	10	11	21
1980	MAR	8	17	25
1980	APR	21	475	496
1980	MAY	25	684	709
1980	JUN	35	615	650
1980	JUL	33	582	615
1980	AUG	33	524	557
1980	SEP	50	489	539
1980	OCT	50	486	536
1980	NOV	47	490	537
1980	DEC	24	286	310
1980	ANN		2,497	2,497
		364	7,180	7,544

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

DETROIT RIVER, MICHIGAN (3301)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1974	JAN	56	169	225
1974	FEB	61	119	180
1974	MAR	54	212	266
1974	APR	65	816	881
1974	MAY	76	1,154	1,230
1974	JUN	83	1,094	1,177
1974	JUL	82	1,076	1,158
1974	AUG	123	1,042	1,165
1974	SEP	98	1,092	1,190
1974	OCT	115	1,147	1,262
1974	NOV	132	1,158	1,290
1974	DEC	162	915	1,077
1974	ANN*	28	3,489	3,517
		1,135	15,105	16,240

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

DETROIT RIVER, MICHIGAN (3301)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1975	JAN	90	281	371
1975	FEB	77	144	221
1975	MAR	76	231	307
1975	APR	96	634	730
1975	MAY	108	1,048	1,156
1975	JUN	118	1,009	1,127
1975	JUL	103	921	1,024
1975	AUG	90	883	973
1975	SEP	97	809	906
1975	OCT	113	871	984
1975	NOV	83	762	845
1975	DEC	74	612	686
1975	ANN		6,176	6,176
		1,125	14,381	15,506

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

DETROIT RIVER, MICHIGAN (3301)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1976	JAN	84	261	345
1976	FEB	66	214	280
1976	MAR	90	222	312
1976	APR	125	605	730
1976	MAY	128	1,000	1,128
1976	JUN	136	1,000	1,136
1976	JUL	139	1,003	1,142
1976	AUG	117	964	1,081
1976	SEP	118	945	1,063
1976	OCT	127	962	1,089
1976	NOV	122	910	1,032
1976	DEC	103	569	672
1976	ANN		6,144	6,144
		1,355	14,799	16,154

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

DETROIT RIVER, MICHIGAN (3301)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1977	JAN	50	149	199
1977	FEB	60	153	213
1977	MAR	69	165	234
1977	APR	88	551	639
1977	MAY	98	1,001	1,099
1977	JUN	126	1,069	1,195
1977	JUL	130	979	1,109
1977	AUG	107	840	947
1977	SEP	90	625	715
1977	OCT	84	644	728
1977	NOV	100	622	722
1977	DEC	94	715	809
1977	ANN		6,429	6,429
		1,096	13,942	15,038

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

DETROIT RIVER, MICHIGAN (3301)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1978	JAN	81	358	439
1978	FEB	94	243	337
1978	MAR	69	161	230
1978	APR	113	560	673
1978	MAY	126	1,026	1,152
1978	JUN	114	969	1,083
1978	JUL	137	1,023	1,160
1978	AUG	115	988	1,103
1978	SEP	105	923	1,028
1978	OCT	102	981	1,083
1978	NOV	100	927	1,027
1978	DEC	86	698	784
1978	ANN		6,689	6,689
		1,242	15,546	16,788

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

DETROIT RIVER, MICHIGAN (3301)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1979	JAN	35	368	403
1979	FEB	31	98	129
1979	MAR	50	112	162
1979	APR	73	550	623
1979	MAY	111	878	989
1979	JUN	102	904	1,006
1979	JUL	80	960	1,040
1979	AUG	63	968	1,031
1979	SEP	98	934	1,032
1979	OCT	95	978	1,073
1979	NOV	95	857	952
1979	DEC	90	582	672
1979	ANN		6,162	6,162
		923	14,351	15,274

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels

DETROIT RIVER, MICHIGAN (3301)

YEAR	MONTH	NUMBER OF TRIPS GROUP-1 VESSELS	NUMBER OF TRIPS GROUP-2 VESSELS	TOTAL NUMBER OF TRIPS
1980	JAN	82	141	223
1980	FEB	56	131	187
1980	MAR	47	204	251
1980	APR	65	709	774
1980	MAY	80	844	924
1980	JUN	86	768	854
1980	JUL	87	702	789
1980	AUG	79	667	746
1980	SEP	90	623	713
1980	OCT	107	628	735
1980	NOV	94	635	729
1980	DEC	59	399	458
1980	ANN		5,047	5,047
		932	11,498	12,430

* Annual - some fleets only report once a year.

Group 1 - Tankers and tank barges
Group 2 - All other vessels